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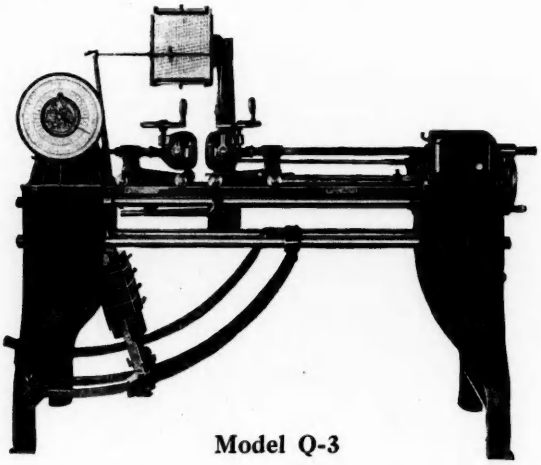

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TEXTILE RESEARCH

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Three Years of Textile Drying Research

By ALBERT C. WALKER*

IT IS KNOWN that the removal of all but a few tenths of a per cent of moisture from fibrous materials is likely to result in more or less permanent changes in the molecular structure of the material; serious damage may occur if the drying is carried out at high temperatures, and even at low temperatures undesirable alterations may occur in the physical properties of the fibres. A fabric dried by contact with a steam-heated drum has a harsh feel and is fairly stiff as compared with one dried by hot air. Furthermore, if a fabric is moistened to too great an extent before calendering (drying under both heat and pressure) it is apt to be thin and have a crisp, papery feel.

These effects illustrate the long-standing economic and quality hazards of drying in the textile industry, and the fact that drying is common to many textile processes prompted members of the United States Institute for Textile Research to enter upon a two-year program of textile drying research. The primary object of this project was to secure information of a fundamental nature which might be of value to the industry at large and not necessarily directed towards the solution of special problems for any one branch of textile manufacture. The program was accepted by representatives of more than fifty textile and allied companies, and funds were subscribed by these companies to carry the work for the two-year period. The results secured were of such value that further funds were forthcoming for an additional year, and the work is now substantially completed for this, the third year.

In a problem so extensive as drying, affecting many branches of the textile industry, it was not expected that this program, conducted by a single research operative for a three-year period, could contribute information on all aspects of textile drying. The fact that the project was so enthusiastically supported for three years rather than for two years as originally planned, and during a period of serious dislocation in all industry, is evidence of the value of the investigation. In fact, there has been considerable demand for a continuation of this program by representatives of some textile industries best equipped to realize on the value of research,

* Chairman, Administration Committee for Drying Research, United States Institute for Textile Research. *Member Technical Staff, Bell Telephone Laboratories, Inc., New York.*

but it appears wise to bring this particular project to a conclusion and to take stock of the results thus far obtained.

Summary of Information Secured

The amount of moisture retained by various textiles when brought to equilibrium with different temperature and humidity conditions provides a basis for determining the limiting moisture contents which may be approached in any specific industrial process involving textiles. Hence, the first year's work was devoted to determining the equilibrium moisture contents of ten representative textiles over a wide range of atmospheric humidities and between 100° F. and 300° F., equilibrium being approached from both the wet state (drying) and from the dry state (reconditioning). There are several different ways of expressing these data graphically, other than by the conventional method of plotting moisture content against relative humidity for each temperature investigated. In the first year's summary report a linear relation between certain functions of moisture content and temperature for each of several humidities in the commercially important drying range was shown to express the data satisfactorily. Other similar linear relations may be used to advantage in the interpolation of values between experimentally determined points, to extrapolate to values outside the experimental range, within reasonable limits, and to apply obvious corrections for occasional experimental errors.

Thus the results of the first year's drying research may be expressed in several useful ways which provide more than merely factual information regarding the amount of moisture retained by a textile under definite temperature and humidity conditions. These data are considered sufficiently reliable and valuable to justify their inclusion in such a standard reference work as the International Critical Tables.

The equipment used in this investigation for measuring the moisture-relative humidity-temperature relations of textiles is described in the June, 1940, issue of TEXTILE RESEARCH and the *Journal of Research* of the National Bureau of Standards. The data themselves, and the more complete discussion of certain linear relations which may be derived from them, will appear in subsequent issues of these publications.

The second year's work was a study of the effects of heat and humidity during drying, upon the properties of purified textiles. Part of the third year was devoted to determining the effects of certain added impurities, such as sizing and carbonizing agents, upon the properties of treated textiles after exposure to definite conditions of heat and humidity during drying. In consequence, much more is now known about how high a temperature a textile fibre can stand during commercial drying, and what are the effects of commonly added impurities upon the physical and chemical properties of the textiles.

As a result of this work it was found that the addition of starch or gelatine to textiles increased their moisture sorption. The addition of acids to wool reduced its moisture sorption, perhaps because salt formation with the basic groups on the protein molecules reduce the affinity of those groups for water. The addition of 0.1% sulfuric acid solution to viscose rayon and cotton did not appreciably change their moisture sorption. The addition of alkalis to wool, cotton and viscose rayon increased their moisture sorption.

Wool cloth which was chrome-mordanted and then dyed exhibited only a small decrease in moisture sorption. Wool cloth which was carbonized

and then dyed had a lower moisture sorption. It is thought that the wool, even though washed, retained a small amount of sulfuric acid, which was sufficient to decrease its moisture sorption. It may be that variations of moisture sorption in wool materials result not so much from an effect of the finishing process on the wool fibre as from the presence on the wool of acids or alkalis used in the treatment and remaining after washing.

Drying the textiles at temperatures above 212° F. generally reduced their affinity for water. No appreciable differences were found in the breaking strengths of wool sized with starch, cotton sized with starch and gelatine, viscose rayon sized with starch and gelatine, and acetate sized with gelatine before and after heating for two hours at 220° F., at a low humidity. Textiles heated with acids or alkalis present on them had lower breaking strengths than similar yarns without these materials. It has not been possible to complete the study of the effect of heating at temperatures above 220° F. on textiles treated with these various agents, but further information of this type should be of considerable value.

One unexpected but important fact has come from this work regarding the effect of humidity during drying. For a given temperature of drying, high humidity has a more harmful effect on the textile fibres than low humidity.

The industry makes extensive use of drying ovens of the "hurricane" type in which heated air is circulated about the textile by means of powerful fans. A large part of textiles dried in such ovens is in the form of packages of yarn. Drying takes place slowly in such packages and the humidity of the air in contact with the material may be either too high or too low, depending upon the degree of ventilation. Recent improvements in the design of such ovens show that the industry is recognizing the need for controlling humidity as well as temperature of the drying air. However, it appears from our work that such advances in the art are only a partial solution of the problem of securing uniform drying without damage to the textile fibres.

A new type of package drying equipment has been developed in the textile industry in which air is blown directly through loose-wound packages, rather than simply circulated around them, and much more rapid and uniform drying is secured with less danger of damage.

As is often the case in pioneering in the arts, the main feature of an advance is first achieved without much thought being devoted to details of efficiency, which comes only with study and refinement in practice. In examining this new type of package drying apparatus it seemed that commercial drying times, while appreciably less than those required in the hurricane-type ovens, were still greater than should be necessary or desirable.

Part of the third year's work was directed toward a study of the drying of package cotton with a laboratory model of this new type of equipment.* This, together with temperature recording equipment,† kindly placed at our service by the industry made it possible to study quantitatively the effects of variations in airflow, temperature and humidity during drying. Temperatures ranging from 165° F. to 305° F. were investigated,

* Drying apparatus supplied by Gaston County Machine Company, Stanley, N. C.

† Temperature recording equipment supplied by the Bristol Company, Waterbury, Conn.

(*Continued on page 461*)

Result Obtained by Use of an Oil-type Size on Viscose Rayon

By WILLIAM E. YELLAND*

A Research of U. S. Institute for Textile Research, Inc.

Summary

A warp which had been slashed with an oil-type size wove very well in the loom, but the results obtained during the desizing and finishing of this warp were poor. The laboratory tests for breaking strength and cohesion indicated that over a period of time a change had taken place in the sized yarn. This change was evident as a marked decrease in the breaking strength of the yarn and in its resistance to abrasion. The poor results in finishing were attributed to changes occurring in the size during ageing. The behavior on ageing of sizes of this nature should therefore be investigated carefully before use, and too much confidence should not be placed in loom tests alone.

Introduction

THE size was described in the literature which accompanied it as a "viscous brown liquid containing 70% of a sulphonated fatty ozonide." In appearance it resembled a partially oxidized linseed oil. Although materials of this type were not employed to an appreciable extent for warp sizing here in the United States, it was reported that in Europe they were used considerably for this purpose. This material was the only representative of this oil-type of size available to the Warp Sizing Project for investigation.

Slashing.—A warp of 125 denier 50 filament bright viscose rayon was slashed on a 5-can rayon slasher using 3 quarts of size in a 10-gallon mix—approximately 7.5% by weight. No softener was used. The size mix had a relative viscosity of 1.36 and a pH 6.9. The warp was dried to 4% regain. As it came off the slasher it was yellow and slightly tacky to touch. Determinations showed 2.9% size present on the yarn.

Weaving.—This warp was used as a pile warp in the fabrication of velvet. It was woven in the same loom as five other warps of similar construction. A complete record of the warp breaks was taken and used to calculate the time per 1,000 picks required by the weaver for tying up breaks in each pile warp only. (See *Tex. Rsch.*, P. 342, June, 1940.) Using these calculations as a means of evaluating weaving efficiency it was found that this warp was second best of the group of six and was considered very good by the weaver.

* Dr. Yelland was director at Massachusetts Institute of Technology of the filament viscose rayon phase of the warp sizing research from Jan. 1, 1936, to Sept. 30, 1938, and is now with Corn Products Refining Co., Research Laboratory, Edgewater, N. J.

In the weave room the warp had a regain of 13.2%. During slashing it had been dried to a regain of 4%. The increase of 9.2% in regain evidently represents the moisture picked up during exposure to the weave room humidity. Samples were taken from the warp during weaving and reserved for laboratory tests.

Desizing and Finishing.—We were advised that the size was most readily removed in a slightly alkaline medium, so the warp was allowed to soak for one-half hour in water adjusted to a pH of 9.8 with ammonia. It was then boiled off in the usual manner, dyed and finished.

During inspection of the finished fabrics, the inspector's report rated this warp as the worst in the group of six warps woven on the same loom. It showed a number of filling bars and the pile also exhibited a ribbed effect which was undesirable. The "hand," however, was satisfactory, and there was no indication of incomplete size removal.

Laboratory Tests

The samples removed during weaving were tested, along with the samples from corresponding warps woven in the same loom, on a Scott Inclined Plane Serigraph.

Sample	Date of Test	Breaking Strength	Standard Error	Residual Elongation	% R.H.
Unsized	June 28	222 grams	± 3 grams	23.9%	63
Sized	June 23	215 grams	± 3 grams	12.9%	60
Unsized	Nov. 18	224 grams	± 3 grams	26.7%	68
Sized	Nov. 18	202 grams	± 4 grams	13.8%	68

The breaking strength of the sized yarn was approximately 3% *less* than the unsized yarn. This was not abnormal for warps intended for pile fabric as samples from warps of this type all showed a decrease in breaking strength due to slashing. The average decrease in breaking strength of a number of samples taken from warps sized with gelatins, starches, gums and resins was 3.6%. This loss is attributed to the mechanical abuse which the yarn undergoes during slashing. In the case of pile fabrics the amount of size applied (usually less than 2%) does not compensate for this loss. In plain goods the larger amount of size applied apparently more than makes up for any loss in strength due to the mechanical abuse of the yarn in slashing, and the net result is usually an increase in breaking strength.

The samples of oil-sized rayon were stored in the laboratory for about six months and the breaking strength again measured. This time it was found that the breaking strength of the sized yarn was now 9.8% less than that of the unsized. The standard error was calculated for each set of determinations and the loss was found to be much larger than the standard error, showing that the loss is really significant. This is a loss of 6% in about five months.

One month after the warp had been woven attempts were made to determine the resistance of the samples to the abrasion and flexing which they receive in the standard Cohesion Tester. However, all the oil-sized samples disintegrated completely at less than 50 strokes. Other specimens, sized with gelatin and starch, did not begin to disintegrate below 500 strokes. The resistance of the warp to friction must have decreased materially since the weaving, otherwise much more difficulty would have occurred during weaving.

Confirmatory Results Reported in the Literature

Since the phenomena of progressive loss of breaking strength and of resistance to abrasion were not found to occur in any of the other samples of the same yarn which had been sized on the same slasher with starch, gelatin-glue, and synthetic resin sizes, it was necessary to attribute them to the effect of the oil size on the rayon. At that time it was not possible to extend the research in order to investigate this phase in greater detail. Consequently the results noted were presented in the confidential reports with the tentative conclusion that the oil size appeared to be the cause of the trouble and that mills should use sizes of this type only with great care. However, these results have been entirely confirmed by articles which have been published since then by other investigators.

H. Roche [1] noted that, when linseed oil-type sizes were used, it was desirable to add small amounts of pinene or cyclohexanol to counteract oxidation effects. W. Weltzien [2] sized viscose rayon samples with various linseed oil sizes and studied the case of desizing, damage to the fibre, and effect on breaking strength. He reported [3] that some rayons are especially sensitive to these oil sizes. J. Rolland [4] attributed the formation of streaks in rayon warps sized with linseed oil sizes to the decomposition of peroxides formed in the oil during drying of the size. He found that the higher the active oxygen value of the oil the greater was the damage done to the yarn. He suggested that the danger of damage could be minimized by storing the oil-sized goods for as short a time as possible and by protecting them against sunlight and heat. Reducing treatment before desizing was also advantageous. Schramek and Scheufler [5] investigated the application of linseed oil sizes to bright and delustred viscose. They reported that the percentage losses in strength and residual elongation were less with the usual water-soluble sizes than with the oil sizes. A similar study [6] on 100 denier filament yarn showed that water-soluble sizes hardly lowered the breaking strength of the rayon yarn even on prolonged storage while linseed oil sizes decreased the strength considerably after only a few weeks. G. Taron [7] also attributed the streakiness of linseed oil finished rayon yarns to oil which had been stored too long. He suggested that the oxidation could be inhibited by formaldehyde or benzene.

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Pectic Substance of Cotton Fibres in Relation to Growth

By ROY L. WHISTLER,* ALBERT R. MARTIN,* and CARL M. CONRAD †

A Textile Foundation Publication

Abstract

The content of pectic substance in cotton fibres at various stages of growth was determined. The results suggest three distinct stages of development of the fibre. The first extends to about the 18th day and is characterized by a gradual decrease in the content of pectic substance. The second extends from the 18th to about the 35th day during which time there occurs a rapid decrease in the content of pectic substance. In the final stage, which extends from about the 35th day to maturity, there is only a slight decrease in the content of pectic substance. These three stages of development are in good agreement with those deduced by other investigators from different types of data.

Introduction

IT has been suggested [1] that the pectic substance of cotton fibres is largely confined to the primary cell wall. Thus it would be expected that very young cotton fibres would contain a high percentage of pectic substance and that the percentage would decrease as fibre development progresses and would reach its lowest value at the time of fibre maturity. It was the purpose of the present investigation to examine this concept quantitatively by following the changes in percentage of pectic substance during the course of the development of cotton fibres.

Materials and Methods

The cotton fibres used in these experiments were collected during the summers of 1937 and 1939, from plants growing in the Experiment Station fields of the U. S. Department of Agriculture at Raleigh, N. C. The cotton was of the Mexican Big Boll variety of *Gossypium hirsutum*. The age of the fibre as collected in the field was determined by tagging the flowers on the day of blooming and then collecting the bolls at definite intervals. As soon as the bolls were picked, they were opened and the cotton fibres removed. The fibres which were to be used for the determination of uronic acids were quickly dried in a stream of warm air. Those used for the determination of pectic substance by the calcium pectate method were not dried but were quickly removed from the bolls at the time of picking and preserved in 80% ethanol.

* Research Associates at the National Bureau of Standards representing the Textile Foundation.

† Senior Cotton Technologist, Agricultural Marketing Service, United States Department of Agriculture.

Uronic acid determinations were made according to the procedure developed by Whistler, Martin and Harris,[2] and the results expressed as percentage of uronic acid-carbon dioxide on the basis of dry weight of the fibres or as percentage of pectic substance. Conversion of uronic acid-carbon dioxide to pectic substance was accomplished by multiplying the percentage of carbon dioxide by the factor 4.8.[2] The size of the samples taken for analysis varied from 2 to 10 g, depending upon the uronic acid content.

In addition to the determination of pectic substance by uronic acid analysis applied directly to the fibres, the 1937 series of fibres were analyzed for pectic substance by means of the calcium pectate method according to the following procedure: The sample (preserved in ethanol) was extracted 4 hours with 90% ethanol in a Soxhlet apparatus. The fibres, after drying in a vacuum oven at 60° C, were subjected to a 30-minute extraction with 100 ml. of a boiling 0.5% solution of ammonium citrate, followed by three successive 30-minute extractions with fresh 100-ml. portions of boiling 0.01 *N* hydrochloric acid. The entire cycle of 4 extractions was then repeated and the filtrates and washings were combined.*

The combined extracts were cooled, neutralized with sodium hydroxide solution, and the pectic substance was determined in an aliquot according to the procedure of Carre and Haynes.[5] The final calcium pectate precipitate was corrected for impurities by the method of Appleman and Conrad.[6]

Experimental Results and Discussion

The pectic substance content in cotton fibres at various stages of growth is shown in Table 1 and Fig. 1. It is seen that the percentage of pectic substance as determined by the calcium pectate method is consistently lower than that found by the direct method of uronic acid analysis. However, since methods of isolation in general give somewhat low results this difference is not unexpected.

An examination of the curves in Fig. 1 reveals that they are composed of three major segments; the first, extending to about the 18th day, indicates a gradual decrease in the percentage of pectic substance with age of the fibre; the second, extending from about the 18th to the 35th day, indicates a rapid decline in the percentage of pectic substance; the third, extending from about the 35th day to the time of maturity, indicates only a slight decrease in the percentage of pectic substance with age of the fibre. It seems probable that each of these periods may be related to particular phases of growth in the development of the cotton fibre. For example, if it is assumed that the pectic substance is largely confined to the primary cell wall, no large change in the percentage of the pectic substance should occur during the period of primary wall formation. However, as non-pectic material, for example cellulose, is deposited in the fibre, the percentage of pectic substance should decrease in approximate inverse proportion with the amount of deposited non-pectic substance.

It has long been recognized that the first phase in the growth of the cotton fibre consists in the development and elongation of the primary cell wall. The time required for the completion of this phase, as measured by Anderson and Kerr [1] for cotton fibres of the Mexican Big Boll variety, is about 20 days. This is very near the age at which the curves in Fig. 1 undergo a sudden and

* The frequent change of solvent and the low concentration of hydrochloric acid were employed [5, 1] to minimize destruction of the pectic substance.

TABLE I

Calcium pectate and pectic substance content of cotton fibres at various stages of growth.

Age of Fibre Days	1937 Series			1939 Series	
	Calcium pectate	Uronic acid—carbon dioxide	Pectic substance content (calc.)	Uronic acid—carbon dioxide	Pectic substance content (calc.)
	%	%	%	%	%
10	4.39	1.24	5.95	—	—
11	4.02	—	—	—	—
12	4.05	—	—	—	—
14	3.95	—	—	—	—
16	3.24	—	—	—	—
17	3.24	1.16	5.57	—	—
18	3.21	1.13	5.43	—	—
19	3.58	1.01	4.85	—	—
20	3.44	—	—	—	—
21	3.12	—	—	—	—
22	—	—	—	1.04	4.99
23	2.39	.73	3.50	—	—
24	—	—	—	.79	3.79
25	1.85	.68	3.22	.60	2.88
26	—	—	—	.47	2.26
28	—	—	—	—	—
30	1.29	.39	1.87	.35	1.68
32	—	—	—	.31	1.49
34	—	—	—	.24	1.15
35	.83	.30	1.44	—	—
36	—	—	—	.23	1.10
39	—	—	—	.24	1.15
40	.62	.19	.91	—	—
42	—	—	—	.18	.86
45	.79	.20	.96	.21	1.00
48	—	—	—	—	—
50	.67	.22	1.06	—	—
51	—	—	—	.22	1.05
54	—	—	—	.21	1.00
0B	—	0.17	0.82	.19	.91

rapid decline. Thus, the present data suggest that no major changes in the composition of the fibre occur during this phase of development.

With the completion of the development of the primary cell wall, the formation of the secondary wall is initiated and a rapid deposition of cellulose commences. This should result in lowering the percentage of pectic substance in the fibre, especially if no appreciable amounts of pectic substance are laid down with the cellulose. The second segment of the curve confirms such an interpretation and further indicates the rate at which the development of

the secondary wall proceeds. This interpretation is also in accord with the work of Berkley,[7] in which it was shown that in cotton fibres similar to those used in this work, the secondary cell wall underwent a rapid thickening between the 18th and 35th days of growth. An examination of the change in the percentage of cellulose with the age of the fibre further substantiates these views.*

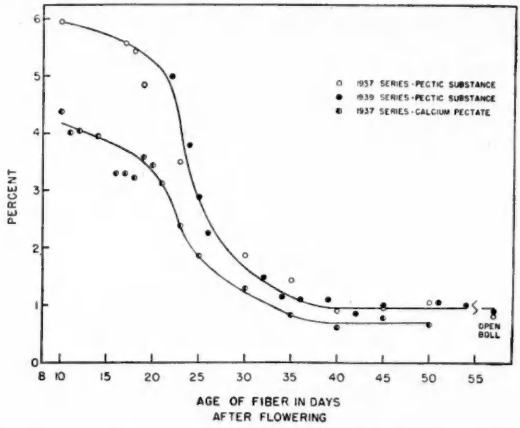

Fig. 1. The content of pectic substance of cotton fibres at various stages of growth. The upper curve was obtained from uronic acid analysis; the lower curve by isolation of the pectic substance as its calcium salt.

From about the 35th day until the boll opened, the content of pectic substance underwent little change, as indicated by the third segment of the curve. This is in agreement with the findings of Berkley,[7] who also showed that no significant change in the ratio of thin- to thick-walled fibres occurred during this period; a fact which indicates that no appreciable change in wall thickness is occurring.

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* This report is in preparation for publication.

Technical Evaluation of Textile Finishing Treatments

III. Use of Rank Correlation for Comparison of Data *

By LELIA J. WINN † and EDWARD R. SCHWARZ, F.T.I.‡

Abstract

The nature and use of the Kendall coefficients of rank correlation and of concordance are presented with details of the methods of computation involved. They are found to be superior to the Spearman coefficient previously used both as a matter of convenience and of statistics. This discussion is given in anticipation of the papers immediately following in this series which will make frequent use of the Kendall rating system.

THE Kendal [1] coefficient of correlation has been adopted as a more efficient measure of rank correlation than that of Spearman.[2] In a distribution where all the possible rankings occur equally frequently the standard deviation of the Kendall coefficient of correlation is less than the standard deviation of the Spearman coefficient. The Kendall coefficient is designated by "τ" and the Spearman coefficient by "ρ." The latter is not distributed normally for a small number (n) of values composing the rank. Since much of the usual work of rank correlation for textiles involves less than 20 values per rank and frequently less than 10 values, use of τ is advantageous since for $n = 6$ or more its distribution approximates the normal. Hence, the determination of the significance of the coefficient may be made by usual statistical methods such as the "t" test which will be discussed in this connection. It is further true that there is a high degree of correlation between ρ and τ so that, while the data of the present experimental work have been re-computed in terms of τ, there has been no change in the general conclusions. They may now be studied much more critically, however, which is important.

When no objective ranking is used as a standard, τ measures the correlation between two rankings by comparing one ranking to the other after it has been placed in objective order. Either ranking may be chosen as objective since the value of τ is the same in both cases. When two stiffness rankings are determined by two different methods and compared, it is not possible to choose one as the standard order, so that this type of correlation is suitable. τ is psychologically correct in its application since it makes a comparison of each member of the rank with the others in that rank, a procedure which is

* This material originally appeared in the Proceedings of the American Association of Textile Chemists and Colorists.

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‡ Professor of Textile Technology, Massachusetts Institute of Technology.

followed in actual handling of the material. It allows a plus mark for each comparison made correctly and subtracts a mark for each error.

τ is derived by the comparison of a ranking (a) with one in the objective order (b) (1, 2, 3 $\cdots$ etc.). Each succeeding number in rank (a) is compared in turn with the succeeding numbers of that rank (a). Each pair of numbers is considered in turn and those in the correct sequence are given a value of + 1, while those in the inverted sequence are given a value of − 1. The sum of these values is denoted as Σ for the rank.

Thus, to compare the ranking of the stiffness values for Bending Length, *c*, against the values for the Flexural Rigidity, *G*,

Rank G = 1 3 2 4 6 5 7 9 8 10
Rank c = 1 5 2 3 4 8 9 7 6 10 (where each number refers to a particular set of specimens.)

the order of *G* may be transposed to the objective order and the corresponding values of *c* are written below.

Rank G (arranged objectively) = 1 2 3 4 5 6 7 8 9 10 n = 10
Rank c (to correspond) = 1 2 5 3 8 4 9 6 7 10

Number 1 of Rank *c* makes nine pairs of numbers in the correct sequence when it is compared with each succeeding number in turn so that its value is + 9. Number 2 makes 8 pairs of numbers in the correct sequence; number 5 makes 5 pairs of numbers in the correct sequence and two in an inverted sequence so that its value is + 3; etc. giving:

Number	Pairs in the Correct Sequence	Pairs in the Inverted Sequence	Value
1	9	0	+9
2	8	0	+8
5	5	2	+3
3	6	0	+6
8	2	3	−1
4	4	0	+4
9	1	2	−1
6	2	0	+2
7	1	0	+1
10	0	0	0
			Σ = +31

The maximum score, which could be made when the rankings are both in the objective order, would be 45 when n = 10.

$$\tau = \frac{\text{actual score}}{\text{maximum possible score}} = \frac{31}{45} = 0.69$$

Generally the maximum score is $(n-1) + (n-2) \cdots + 1 = \frac{n(n-1)}{2}$.

Thus,

$$\tau = \frac{2\Sigma}{n(n-1)} = \frac{62}{90} = 0.69.$$

A shorter method is used in actual practice. Suppose Rank "G" is transposed to the objective order and Rank "c" is transposed to correspond. As seen

above it will be

$$\text{Rank c} = 1\ 2\ 5\ 3\ 8\ 4\ 9\ 6\ 7\ 10 \qquad n = 10$$

Considering Rank "c" we note that there are 9 figures to the right of "1" which are greater than "1."

Similarly, there are 8 figures to the right of "2" which are greater than "2"; 5 figures to the right of "5" which are greater than 5, etc. giving

(To the right of)	(Number of greater figures)
1	9
2	8
5	5
3	6
8	2
4	4
9	1
6	2
7	1
10	0
	Sum = 38 = K

If the rankings were the same, so that both were in the objective order after "G" was transposed, the sum would be 45. Thus, to find the number of figures lying to the right of successive numbers in the rank which are *less* than these numbers in magnitude we subtract K from 45. Giving $45 - K = 7$ which is the sum of number of lesser figures.

Since we have taken Σ to equal the difference between the number of figures which are greater and the number of figures which are less than the noted values, then

$$\Sigma = 38 - 7 = 31$$

which agrees with the result obtained by scoring $(+1)$ and (-1) as already shown.

In general

$$\Sigma = 2K - \left[\frac{n(n-1)}{2}\right]$$

or

$$2(38) - \left[\frac{10(10-1)}{2}\right]$$

and

$$\Sigma = 76 - 45 = 31.$$

There are several other methods of computing Σ which are of value in other circumstances. For these the reader is referred to *Biometrika XXX*, June (1938).

It has already been stated that it makes no difference which rank is arranged objectively. For instance, if Rank c were so arranged rather than Rank G, we would have

Rank c (arranged objectively) = 1 2 3 4 5 6 7 8 9 10 $\qquad n = 10$
Rank G (to correspond) = 1 2 4 6 3 8 9 5 7 10

and

(To the right of)	(Number of greater figures)
1	9
2	8
4	6
6	4
3	5
8	2
9	1
5	2
7	1
10	0
	Sum = 38 = K

and as before

$$\Sigma = (2)(38) - 45 = 31$$

It is possible to check a computation by counting the greater numbers to the left and then

$$\Sigma = \frac{n(n-1)}{2} - 2l.$$

The Kendall rating as compared to the Spearman rating given in a previous paper [2] follows:

Kendall Rating

Formula: $\tau = \frac{2S}{n(n-1)}$ $\quad S = 2\Sigma K - \frac{n(n-1)}{2}$

Case 1 ($\tau = +1$)

A	B	K
1	1	4
2	2	3
3	3	2
4	4	1
5	5	0
		K = 10

$S = 20 - 10 = 10$

$\tau = \frac{20}{20} = +1$

*Case 2** (Spearman) $\rho = 0$)

A	B	K
7	5	0
2	1	3
3	2	2
4	3	1
5	4	0
		K = 6

$S = 12 - 10 = 2$

$\tau = \frac{4}{20} = .20$

*Case 2** (Kendall) $\tau = 0$)

A	B	K
1	5	0
2	1	3
3	2	2
4	4	0
5	3	0
		K = 5

$S = 10 - 10 = 0$

$\tau = \frac{0}{20} = 0$

Case 3 (-1)

A	B	K
1	5	0
2	4	0
3	3	0
4	2	0
5	1	0
		K = 0

$S = 0 - 10 = -10$

$\tau = -\frac{20}{20} = -1$

* Case 2 in Spearman = 0. But since Spearman distribution is not normal when n is so small, it is seen that where a Spearman ranking $\rho = 0$, the Kendall gives $\tau = .20$. A more random distribution gives $\tau = 0$ while Spearman would be $\rho = .10$.

The t-test where $t = \sqrt{\frac{\tau(n-2)}{1-\tau^2}}$ may be used as a test for significance for both Spearman's ρ and Kendall's τ. However, ρ must be corrected to $X = \frac{\Sigma d^2}{1/6(n^3-n)+1} - 1$ for continuity when n is small. There are $n-2$ degrees of freedom. If the value of t is greater than that shown at the .025 level of significance, the two rankings are significantly alike.

Thus when $n = 10$, there are 8 degrees of freedom and 2.31 is indicated at the .025 level.

Spearman $\Sigma d^2 = 62$	$\rho = 62.5\%$	$t = -2.27$ is not significant
$\Sigma d^2 = 60$	$\rho = 63.8\%$	$t = -2.35$ is significant
Kendall $\Sigma K = 33$	$\tau = 47\%$	$t = 2.20$ is not significant
$\Sigma K = 34$	$\tau = 51\%$	$t = 2.35$ is significant

but values near the level are too close and indicate a need for more specimens.

Sample Designation [3]

AcTK	Treated Thick Cotton
PTK	Plain Thick Cotton
TCl	Tracing Cloth
ULO	Unlaundered Organdie
LO	Laundered Organdie
AcC	Treated Congo Cloth
PC	Plain Congo Cloth
AcTh	Treated Thin Cotton
PTh	Plain Thin Cotton
V	"Velvet," pile fabric

A comparison of the Spearman ρ and Kendall τ values in the tests already published confirms that the pairs shown to be probably significantly alike by Spearman rating actually are alike.

Rankings

	Bending Length	Rigidity	Bending Modulus	Schiefer Flexometer	Chord Length (Drape Tester)	Radius of Curvature (Drape Tester)	Gurley Flexometer
AcTK	1	1	3	1	1	1	1
PTK	5	3	8	3	2	2	2
TCl	2	2	1	2	10	10	4
ULO	3	4	2	5	3	4	9
LO	4	6	4	7	4	3	10
AcC	8	5	7	6	6	6	3
PC	9	7	9	8	7	5	5
AcTh	7	9	6	9	8	7	7
PTh	6	8	5	4	9	9	8
V	10	10	3	10	5	8	6

SPEARMAN ρ

	Bending Length	Rigidity	Chord Length (Drape Tester)	Radius of Curvature (Drape Tester)	Schiefer Flexometer	Gurley Flexometer
Gurley Flexometer	.12	.55	.25	.25	.43	—
Schiefer Flexometer	.82	.88	.21	.25	—	
Radius of Curvature (Drape Tester)	.35	.47	.90	—		
Chord Length (Drape Tester)	.30	.42	—			
Rigidity	.82	—				
Bending Length	—					

KENDALL τ

	Bending Length	Rigidity	Chord Length (Drape Tester)	Radius of Curvature (Drape Tester)	Schiefer Flexometer	Gurley Flexometer
Gurley Flexometer	.07	.38	.20	.16	.38	—
Schiefer Flexometer	.69	.82	.20	.25	—	
Radius of Curvature (Drape Tester)	.20	.42	.87	—		
Chord Length (Drape Tester)	.16	.38	—			
Rigidity	.69	—				
Bending Length	—					

The rankings are from stiffness values which are the grand averages of the readings obtained in testing the front and back of each fabric in each direction. In the previous paper only the averages of the front readings were available and in some cases the ranking only has been changed.

The foregoing treatment has dealt with the comparison of two ranks only. Kendall [4] has suggested also a coefficient of concordance, W, to use when there are more than two (or "m") rankings to be compared. W is derived from a consideration of the sums of the columns in the "m" rankings. If the rankings were similar the sums would be $m \times 1$, $m \times 2$, $m \times 3$, etc. If the rankings had no relationship the numbers in the columns would occur at random and the sums obtained with m rankings would tend to be equal. W is a comparison of the sums obtained with "m" rankings to the maximum possible values of the sums which are present when the rankings are all in exactly the same order. W varies from + 1 to 0.

Taking the stiffness rankings obtained by the different testing methods we have m = 6, n = 10.

Bending Length	1	5	2	3	4	7	6	8	9	10
Rigidity	1	3	2	4	6	9	8	5	7	10
Chord Length (Drape Test)	1	2	10	3	4	8	9	6	7	5
Radius of Curvature (Drape Test)	1	2	10	4	3	7	9	6	5	8
Schiefer Flexometer	1	3	2	5	7	9	4	6	8	10
Gurley Flexometer	1	2	4	9	10	7	8	3	5	6
sums = u =	6	17	30	28	34	47	44	34	41	49 ... Σu = 330
squares of sums = u^2 =	36	289	900	784	1156	2209	1936	1156	1681	2401 ... Σu^2 = 12,548

The sum of each column (u) shows the amount of correlation between the rankings. Perfect correlation would give 6, 12, 18 $\cdots$ 60, although not necessarily in that order. With less correlation the values of u would all be about 33. The Σu is fixed for m = 6, n = 10 but the sum of u^2 varies with the values of u.

The variance of these sums is the sum of the squares of the deviations of the values of u from their mean which is

$$\text{Mean} = \frac{m(n+1)}{2}$$

Thus, if we let S denote the variance of the sums we have

$$S = \Sigma u^2 - \frac{(\Sigma u)^2}{n}$$

or, for the example noted,

$$S = 12548 - \frac{(330)^2}{10}$$

$$S = 1658.$$

Now the largest value possible for S is obtained when the rankings are all alike, as

$$S_{Max} = \frac{m^2(n^3 - n)}{12}$$

and

$$W = \frac{S}{S_{Max}} = \frac{12S}{m^2(n^3 - n)}$$

or for the example noted

$$W = \frac{12(1658)}{35640} = 0.56$$

To determine the significance of the coefficient of concordance (W) we may use the usual Z test of statistics for the significance of a variance where

$$Z = \tfrac{1}{2} \ln \frac{(m-1)W}{1 - W}$$

also

$$n_1 = (n - 1) - \frac{2}{m}$$

and

$$n_2 = n_1(m - 1)$$

Thus, for the example noted,

$$Z = \tfrac{1}{2} \ln 6.4 = 0.93$$
$$n_1 = (10 - 1) - \tfrac{2}{6} = 8\tfrac{2}{3}$$
$$n_2 = (8\tfrac{2}{3})(6 - 1) = 43\tfrac{1}{3}$$
$$f_1 = n_1 - 1 = 7\tfrac{2}{3}$$
$$f_2 = n_2 - 1 = 42\tfrac{1}{3}$$
$$Z_c = < 0.6$$

Since $Z = 0.93$ is greater than $Z_c < 0.6$ the rankings are significantly the same.

When m and n are small, it is necessary to correct "W" for continuity and W′ is used in its place, thus

$$W' = \frac{S - 1}{\frac{m^2(n^3 - n)}{12} + 2}$$

or

$$W' = \frac{1657}{\frac{35640}{12} + 2} = 0.56$$

To illustrate the use of the Kendall coefficient of concordance (W) consider the following simple cases of three ranks of five items each.

For Case 1:

A	1	2	3	4	5
B	1	2	3	4	5
C	1	2	3	4	5
u =	3	6	9	12	15
u^2 =	9	36	81	144	225

$\Sigma u = 45$ and $(\Sigma u)^2 = 2025$

$\Sigma u^2 = 495$

or

A	1	4	3	2	5
B	1	4	3	2	5
C	1	4	3	2	5
u =	3	12	9	6	15
u^2 =	9	144	81	36	225

$\Sigma u = 45$

$\Sigma u^2 = 495$

and

$$S = 495 - \frac{2025}{5}$$
$$S = 90$$
$$W = \frac{1080}{1080} = +1$$

This indicates perfect agreement.

For Case 2:

A	1	2	3	4	5
B	3	4	5	1	2
C	5	3	1	4	2
u =	9	9	9	9	9
u^2 =	81	81	81	81	81

$\Sigma u = 45$ and $(\Sigma u)^2 = 2025$

$\Sigma u^2 = 405$

and

$$S = 405 - \frac{2025}{5}$$

$$S = 0$$

$$W = \frac{0}{1080} = 0$$

which indicates no similarity in the rankings.

The value of rank correlation, for the analysis of data of the sort obtained by any one type of test on two or more series of specimens which are to be classed in definite order of excellence, is evident. The technique is not widely familiar and the application of the method has only infrequently been applied to problems arising as a result of textile research. Not only, therefore, is the foregoing of interest and importance for the present work, but also for other investigations where data must be similarly presented.

References

1. *Biometrika, XXX*, June, 1938.
2. *Text. Rsch., X*, No. 1, P. 14–16 (1939).
3. *Text. Rsch., X*, No. 1, P. 14, Table 2, (1939).
4. *Annuals of Mathematical Statistics, X*, No. 3, (1939).

(*Continued from page 445*)

with airflows from 5 to 33 cubic feet per minute, and relative humidities from 5 to 30% at these high temperatures.

Drying times proved to vary from 9 hours down to 15 minutes, in contrast to 12 to 20 hours for the hurricane-type ovens, and the drying period decreased as the temperature and airflow increased and the relative humidity decreased. Analyses of the data on rates of drying indicate that there are certain linear relations between airflow, temperature and humidity, and that airflow is the most important factor. The data not only gave detailed information on package drying, but also general information on the mechanism of drying; upon these bases it was possible to bring out certain limitations in new methods of drying which were brought to the attention of our committee for consideration and to suggest modifications in these methods leading to greater drying efficiency.

The cost of drying packaged yarn was also determined for the different drying conditions on the basis of electrical and steam costs. In general, for the particular drier used in our experimental work, it appeared that temperatures of 210 to 255° F., with airflows in the neighborhood of 10 to 20 cubic feet per minute gave the best and most economical results. Five cubic feet per minute is about the highest air velocity now used in commercial equipment. Thus, these data emphasize the importance of increasing airflow instead of temperature, within certain limits, so as to decrease both drying time and operating costs.

Relations Between the Food and Silk of Silkworms

By WERNER BERGMANN *

A Textile Foundation Publication

Introduction

MULBERRY LEAVES are the preferred food of the silkworm, *Bombyx mori*, and also the only one with which results of practical seri-cultural importance have as yet been obtained. From time to time attempts are made to substitute or supplement mulberry leaves by leaves of other plants. Studies along this line are of considerable interest since the discovery of a good and cheap substitute for mulberry leaves may well reduce the cost of silk production and also permit sericulture in regions where climatic conditions are not altogether too favorable for the growth of mulberry trees.

Substitutes for Mulberry Leaves

It has been known for some time that the leaves of *Maclura aurantiaca*, the osage orange, a plant related to the mulberry tree, are readily consumed by the silkworms. The leaves offer sufficient nourishment to permit the worms to grow, spin cocoons, pupate and complete their life cycle. Worms raised on osage orange leaves are, however, of inferior health and show a very high mortality, up to 80%. In addition the silk produced by the surviving worms, although in many respects similar to ordinary silk (Colombo [9]) is of inferior quality and weighs 40% less than the silk of the mulberry-fed controls (Vecchi).[64] Vecchi also found that it was impossible to accustom silkworms to osage orange leaves by using these leaves as the exclusive diet for five successive generations. The difference in the nutritife value of osage orange and mulberry leaves becomes evident by the fact that worms which are of poor health because they have been fed osage orange leaves exclusively recover rapidly when given mulberry leaves. Oliver [47] is of the opinion that it is only the young and immature leaf of the osage orange bush which does not agree with the worm. He believes that if the worms were permitted to make their own selection osage orange leaves could indeed serve as a satisfactory substitute for mulberry leaves. The leaves of another plant related to the mulberry tree, namely *Broussonetia papyrifera* or the paper mulberry, can also be used as a temporary substitute for mulberry leaves.

In Central Europe considerable attention has been paid to the leaves of *Scorzonera hispanica*, the black salsify, as a suitable substitute for mulberry leaves. The claims which had been advanced in favor of such a diet for

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silkworms, however, could not be corroborated by critical investigators. Demjanovsky and collaborators,[12] for example, found the worms which received Scorconery leaves exclusively reached the third age only without considerable losses. From then on the mortality increased so rapidly that only a few worms reached the fourth age. The authors are of the opinion that it is the acidity of the juice of the Scorconera leaves, P_H 5.5–6.1, which is responsible for the rate of mortality. When fed ribs only which are of even higher acidity, P_H 5.0–5.5, all worms died before having reached the first moult. If, however, the worms were supplied with leaves which had lost some of their acidity during 24 hours of wilting, P_H 6.2–6.7, they thrived well enough to complete the larval stage. But here again the size and quality of the cocoons produced were of decidedly inferior grade.

In Table 1 the chemical composition of mulberry leaves is compared with that of the substitutes mentioned so far. The data presented in this table are based on studies made by Colombo.[10]

TABLE 1

Comparison of the Chemical Composition of Mulberry Leaves and Substitutes.

Plant	Ash	100 gm. of dried leaves contain			
		Fats	N	Proteins	Pentosans
Maclura aurantiaca.....	9.96 gm	1.87 gm	3.74 gm	23.37 gm	——
Scorzonera hispanica.....	11.25 "	2.66 "	2.91 "	18.19 "	8.37 gm
Broussonetia papyrifera..	17.13 "	3.11 "	4.82 "	30.12 "	6.80 "
Mulberry.....	7.22 "	4.01 "	——	21.8 "	7.38 "
	13.57 "	5.93 "		31.1 "	10.75 "

Several investigators, as for example Kellog and Thompson [63] succeeded in obtaining cocoons and pupae from worms raised on lettuce leaves exclusively. The newly-hatched larvae adopted this strange diet with some hesitation. Later in life, however, they consumed lettuce leaves as readily as mulberry leaves. The most striking effect of the lettuce diet was an extraordinary prolongation of the larval stage. It lasted three months instead of the normal period of four to six weeks for mulberry-fed worms. The worms raised on lettuce leaves possessed a rather thin skin and at spinning-time they were considerably heavier than the mulberry-fed controls. The silk produced by worms raised on lettuce was only half as heavy as that of the average silkworm raised in the normal manner. For obvious reasons the raising of silkworms on lettuce alone will never assume any practical, sericultural importance. The fact, however, that young worms can be kept alive on a lettuce diet can occasionally assume some importance. Once during the investigations of the writer of the present report unfavorable climatic conditions retarded the appearance of mulberry leaves until two weeks after the eggs had hatched. It was possible to keep most of the worms alive by feeding them lettuce until mulberry leaves became available. Thereafter the worms developed in the normal manner and gave cocoons of average size and quality.

There exist some races of *Bombyx mori* which are not quite as particular in regard to their diet as others. One race, for example, is raised by the natives of certain regions in China on a mixture of mulberry leaves and leaves of *Cudronia triloba*. This "Cudronia Race" can also be raised successfully on Cudronia leaves alone (Sasaki).[60] The quality and quantity of silk produced by these worms is not inferior to that of ordinary Japanese worms. As far as the more common varieties of *Bombyx mori* are concerned, however, mulberry leaves cannot be replaced to any advantage by Cudronia leaves. Worms raised on such a diet show a slow growth and a poor production of silk (Bito).[3] This is probably due to the fact that Cudronia leaves contain less protein than mulberry leaves (Bito)[3] and that the protein is different from mulberry leaf protein (Nakasone).[45]

It has been claimed that silkworms can be induced to consume apple, plum or peach leaves which have been wetted by the juice of mulberry leaves. It would be of interest to ascertain whether worms raised on such a diet complete their life cycle and produce silk of average quality and quantity.

As a rule wild silkworms are not quite as closely restricted to one food plant as the worms of *Bombyx mori*. Nevertheless even among wild silkworms there exist some close relations between the type of leaves, the growth of the worms and the quality and quantity of silk production (Bito[4] and Kitzawa[40]).

Very little as yet is known in regard to the question why certain leaf-eating insects, as for example the silkworm, are restricted to one food plant. Campbell[5] has offered the following three possible explanations for this phenomenon:

(1) Such an exact coadaptation may exist between the feeding mechanism of the insect and the adapted foliage that it may be mechanically impossible for the insect to feed on leaves differing structurally from those of the chosen food plant.

(2) The sense organs controlling the feeding mechanism may be so delicately adjusted to stimuli from accepted foliage that other leaves may not supply stimuli requisite for setting the feeding mechanism in action or if the insect can attempt to eat, the repellant taste of the unusual foliage may prevent further eating.

(3) If the foliage not normally consumed is eaten, it may lack the proper components for growth or maintenance, may not be sufficiently digested, or may even exert a toxic effect.

Supplementary Foods

As has been demonstrated by the investigations described in the preceding paragraphs a suitable substitute for mulberry leaves still remains to be discovered. In more recent years the quest for improving the quality and quantity of silk has shifted to a certain degree from the search for a substitute for the mulberry leaf to a study of the effect of various supplementary food materials of organic or inorganic nature on the growth and silk production of the silkworm. Attempts along this line were begun a long time ago by the Chinese who are said to have improved the nutritive value of the mulberry leaf by an addition of rice starch. In a recent investigation Hartmann and Wong[16] have asserted that the feeding of silkworms with mulberry leaves covered with soya bean milk is beneficial to

silkworms of the last age. They have stated that the worms were not only comparatively free from disease but produced more silk than the controls. These interesting investigations were continued on a larger scale by Wong,[46] who supplemented mulberry leaves not only by soya bean milk of different concentrations but also by beef extract, peptone and pea leaves. According to Wong, the worms which received the supplementary diet seven times during their larval stage did not differ noticeably from the controls. Spinning, pupation, emergence from the cocoon and oviposition took place at approximately the same time. A comparison of the mortality of the worms and pupae and the amount of silk produced by the worms fed with the various diets as well as their controls are shown in Table 2.

TABLE 2

Effect of Supplementary Diets on the Mortality of Bombyx Mori and the Production of Silk.

Type of Supplementary Diet	Mortality of		Weight of silk
	Larvae	Pupae	
Controls	100	100	100
Beef Extract	161	112	109
Pea Leaves	92	240	106
Soya Bean Milk Dilute	77	112	101
Soya Bean Milk Concentrated	70	77	110
Peptone	70	111	107

The Japanese investigator Naruse[46] has taken out a patent covering the preparation of a complete synthetic substitute for mulberry leaves. This artificial diet consists of a soya bean paste prepared by a special process and the juice of mulberry leaves. No information is as yet available concerning the sericultural value of this patent.

The effect of the addition of carbohydrates like starch, glucose and sucrose to mulberry leaves has frequently been investigated. Hiratuka[18] found that starch is hardly utilized. This observation indicates that the old Chinese method of feeding silkworms mulberry leaves sprinkled with rice starch is of little practical value. Glucose and sucrose, on the other hand, are readily absorbed and biochemically transformed into glycogen and fat. Excessive supply of carbohydrates, however, is rather detrimental to the health of the worms as well as the yield of silk and eggs (Hiratuka).[18]

In as much as silk is a protein containing considerable quantities of glycine, a study of the influence of the addition of glycine to the leaf diet at once suggested itself to the experimental sericulturist. It was quite within the realm of possibility that such an addition could have a beneficial effect on the silk production. The problem was investigated by Pigorini,[52] who fed silkworms with leaves wetted by a 2.5% solution of glycine. The results of his experiments have led Pigorini to the conclusion that worms resorbed and assimilated the glycine, and that the silk of worms raised in such a manner contained more fibroin and nitrogen than normal silk. When

fed higher concentrations of glycine, however, most of the worms died before reaching the spinning stage.

The influence of cholesterol on the growth of silkworms has been investigated by Araki.[1] He observed that worms which had been fed on a diet of mulberry leaves supplemented by either cholesterol itself or by egg yolk which is rich in cholesterol, were more slender than the controls. The cocoons were lighter, but since the pupae were also of subnormal weight, the relative amount of silk produced was much higher than that of the controls. The author also claims that the silk produced by cholesterol-fed worms possesses a superior color, lustre and elasticity (see also Kato) [24]

Campbell [5] made the rather remarkable observation that the life of the silkworm can be sustained to some extent by a highly nutritious food of animal origin. He fed worms on drops of cow's milk alone and found that they lived about a week longer than starved or water-fed controls. This bears out the fact that silkworms can obtain some nourishment out of milk.

In this connection it may be mentioned that Carbone and Fortuna [7] have tried to "vaccinate" silkworms against flacerie and grasserie by placing them on a diet of mulberry leaves sprinkled with certain vaccines. While their preliminary results were not entirely discouraging, other investigators obtained negative results only. Sacchi,[57] for example, found the "vaccinated" worms to show a somewhat higher mortality and an inferior cocoon production than the controls.

Of the inorganic materials calcium seems to have some beneficial effect on silkworms. Hatano [17] fed worms mulberry leaves which had been sprayed by an aqueous solution of 5% calcium bicarbonate, calcium chloride and calcium acetate (10.7 cc. per 100 mg. of leaves). The leaves which had been dried long enough to evaporate the solvent were given to worms which had just completed their fourth moult. In each group the weight of 100 live worms, cocoons, pupae and silk was greater than that of 100 controls. One hundred dried mature bodies were from four to eight grams, and 100 live cocoons from three to four grams heavier than the controls. The amount of silk produced showed an increase of from 5 to 7% above normal. In all instances the calcium content of worms and cocoons was increased from 3 to 25%.

Cavazza [8] studied the effect of the addition of various salts, bases and acids to the mulberry diet of silkworms. He found that such compounds as potassium and sodium hydroxide, copper sulfate, ferrous sulfate and chloride had little effect on the duration of the larval period, and that hydrochloric and oxalic acid as well as cobalt chloride increased the number of moultings by one. All compounds showed a detrimental effect on the silk production.

Practically all of the experiments dealing with supplementary food for silkworms have given results which must be regarded as questionable from a practical as well as a scientific point of view. It cannot be advisable to draw far-reaching conclusions from the results of unsystematic, isolated experiments without their having been checked at various places of sericultural research. The studies mentioned in the preceding paragraph must be considered as pioneer work only, as some preliminary attempts to direct sericultural research into new channels. Looked at from such point of view they assume some importance to the student of sericulture.

In future investigations along this line it should be mandatory to eliminate all such feeding methods which permit the worms to consume un-

known quantities of testing material as well as mulberry leaves, and to replace them by more quantitative methods. Campbell[6] deserves credit for having introduced the first feeding methods of some definite quantitative value. One of the methods consists in the direct oral application of the accessory food material by means of a specially designed pipette. Another method, not quite as accurate, but more practical is the so-called sandwich method. Here a piece of mulberry leaf is surfaced as evenly as possible by the test material and then covered by another piece of leaf. By applying a little pressure a "sandwich" can be formed which is as a rule readily eaten by the worm.

Types of Mulberry

The evidence presented in the preceding paragraphs demonstrates that at present the unadulterated mulberry leaf must be regarded as the most suitable food for the silkworm *Bombyx mori*. There are two principal types of mulberry with which practical sericultural results have been achieved, namely, *Morus nigra*, the black mulberry, and *Morus alba*, the white mulberry. The differences in the sericultural importance between the leaves of these two types of mulberry have been the subject of many investigations. Quajat,[56] for example, has found that while the quantity of silk produced by worms raised on the black mulberry hardly differs from that produced by worms raised on white mulberry, its quality is decidedly inferior. Apart from this disadvantage the leaves of *Morus nigra* also tend to increase diseases such as grasserie (Ertogroul).[15] For these and other reasons, therefore, the leaves of the white bulberry are far superior to those of the black mulberry.

Of *Morus alba* numerous varieties are known, the discussion of which would go beyond the scope of this report. It may suffice to state that the leaves of the wild *Morus alba* are not to be recommended in spite of the fact that they give healthy worms and excellent silk (Sasaki).[61] The wild mulberry is uneconomical because of its paucity of leaves, and also because the leaves wilt too rapidly (Verson,[65] Quajat and Jordanoff).[56] Wherever wild mulberry trees are available it is advisable to graft cultivated varieties upon them in order to obtain a better crop of leaves.

Maturity of the Mulberry Leaf and Its Nutritive Value

The nutritive value of the mulberry leaf is conditioned by a great many factors, for example, age, climate, season, exposure to light and composition of soil. Kellner and collaborators[35] (1884) were the first to emphasize the importance of the chemical changes which the mulberry leaf undergoes during maturation. They determined the average composition of the leaves given to worms of each of the five different ages. The data obtained by these authors are shown in the first five columns of Table 3. They picture the average changes in the composition of the leaf during a period of approximately one month. As can be readily seen the amount of dry matter of the leaf shows a steady increase during this time. The protein and fat content of the dry matter decreases while its nitrogen-free extracts, ash and fibrous materials increase.

The changes undergone by the mulberry leaf during its process of maturation must necessarily have some effect on its nutritive value to the

TABLE 3

Comparison of the Composition of Various Types of Mulberry Leaves.

Fraction	Leaves corresponding stages of silkworms [5]					Silo leaves [1]	Sick leaves [2]	Leaves		Fall leaves	
	I	II	III	IV	V			Green	Yellow [3]	A.M.	P.M.[4]
% of dry matter	24.41	25.11	24.55	25.90	29.28	34.62	26.6	35.5	31.7	31.58	34.85
Crude protein	32.89	29.83	29.00	27.84	25.00	24.75	—	—	—	—	—
Crude Fat	5.15	5.51	4.88	4.14	3.25	4.98	3.41	5.13	6.03	5.52	5.44
Crude Fibre	9.80	10.35	11.34	11.57	10.44	12.62	12.78	12.84	14.06	—	—
N-free Extract	44.46	46.89	46.78	47.51	52.47	47.19	—	—	—	—	—
Ash (C and CO_2 free)	7.70	7.42	8.00	8.94	8.84	8.96	12.70	8.78	9.21	—	—
Total N	5.26	4.77	4.64	4.45	4.00	3.96	4.19	3.95	2.45	2.44	2.53
Protein N	3.90	3.75	3.83	3.61	3.36	3.56	3.78	3.84	2.08	—	—
Non-Protein N	1.36	1.02	0.81	0.84	0.64	0.40	0.41	0.11	0.37	0.11	0.16

[1] See Landi ref.
[2] Leaves affected by Diaspis, see Pigorini ref.[52]
[3] See Ongaro ref.[48]
[4] See Pigorini.[51]
[5] See Kellner ref.[35]

silkworm. The scope of such an effect has been extensively studied in recent years by Kishi [26–30] and other investigators. Kishi was mainly interested in the alteration of proteins during the ageing of the mulberry leaf. He divided the leaf proteins into two groups according to their solubility. Group A contained all proteins which are soluble in distilled water, an aqueous solution of 10% sodium chloride, 70% ethyl alcohol and 0.2% sodium hydroxide. Group B consisted of the residual protein which was soluble in boiling 60% ethanol containing 0.3% sodium hydroxide (Kishi [26]). The data obtained for the contents of these proteins in leaves, stems and sap are shown in Table 4.

TABLE 4

Comparison of the Protein Content of Different Parts of the Mulberry Leaf.

Substance in %	Leaves	Sap	Stems
Total protein nitrogen (Stutzer)	100	100	100
N of H_2O extract pptd. with Cu $(OH)_2$ (1)	15.12	88.76	19.94
N of extract with 10% NaCl sol.	7.46	4.22	18.07
N of extract with 70% alcohol (3)	4.41	0.85	9.00
N of extract with 0.2% NaOH (4)	5.01	1.63	10.40
Total N of 1–4 (Protein A)	32.00	95.46	57.41
N of residue extracted with boiling alcaline dil. ethanol (Protein B)	62.34	2.17	42.16
N of 25% hot HCl extract from residue	3.26	1.32	1.11
N of final residue	0.56	0.31	1.05

Kishi [27] corroborated Kellner's observations in regard to the decrease of total protein during the maturation and showed in addition that the balance between the proteins A and B gradually changed in favor of the latter (Table 5). The alterations were somewhat variable, depending on

TABLE 5

Changes in the Relation between Protein A and B during the Maturation of the Mulberry Leaf.

Protein	State of Leaves			
	Very young	Young	Mature	Overmature
A	100	100	100	100
B	442	470	607	721

the rate of growth and other factors. The practical importance of Kishi's observations lies in the fact that protein B is less digestible by the gastric fluid of the silkworm than other proteins. Hence the digestibility of the proteins of younger leaves, in which protein A predominates is superior to that of more mature leaves, which are richer in protein B (see Table 6).

TABLE 6

Digestibility of the Total Proteins.*

Degree of maturity	Gms. of protein for 100 worms of the 5th age					% of digestibility
	Total amt. of food	Unconsumed food	Consumed	Feces	Resorbed	
			Spring Race			
Young....	91.90	21.15	70.74	16.24	54.51	77.05
Mature...	91.51	21.40	70.11	17.44	52.67	75.13
Old.....	91.21	23.35	67.86	18.64	49.23	72.54
			August Race			
Young....	80.23	15.65	64.58	16.82	47.76	73.95
Mature...	80.01	16.69	63.32	18.31	45.01	71.08
Old.....	75.93	17.98	57.95	19.00	38.95	67.21
			September Race			
Young....	87.34	24.82	62.52	18.47	44.05	70.59
Mature...	88.60	27.91	60.69	20.40	40.86	66.39

* (*The amt. of protein was determined by Stutzer's method.*)
In a different set of experiments the degree of digestibility of protein was found to be 79.13 for very young leaves; 78.91 for very young leaves plus sugar; 73.91 for mature, and 65.88 for old leaves.

Kishi [28] has also demonstrated that the feeding of silkworms with young leaves increases the protein content of the dry weight of the body, the absolute weight of the silk gland and its relative weight in comparison to the total weight of the body. Hence the silk production of worms raised on young leaves is greater than that of worms raised on older leaves. The superiority of younger leaves over older leaves also depends on their higher content of cell sap which contains most of the easily digestible protein A (Imamura).[22]

Very young leaves, although rich in digestible proteins, are nevertheless of inferior nutritive value because of their deficiency in soluble carbohydrates (Kato).[23] Worms raised on such young leaves show a markedly increased rate of protein metabolism (Kishi) [33] as evidenced for example by an increase in the excretion of uric acid (see Table 7). Lack of digestible carbohydrates therefore compels the worm to utilize to some extent the protein reserves. This protein consumption can be decreased by supplementing the diet of very young leaves by an addition of sugar.

Kishi [35] has also found that there exists some definite relation between the degree of maturity of the leaf and the composition of the silk. The silk produced by worms which had received very young leaves only during their fifth age was very rich in sericin (see Table 8). On supplementing the very young leaves with sugar the quantity of silk production is increased and the sericin content of the silk is decreased. These observations demonstrated convincingly the intimate connections between the carbohydrate and protein metabolism.

TABLE 7

Relation Between the Total Amount of Uric Acid in Excrements and the Maturity of the Leaves Given to the Worms. (Kishi.) [32]

Type of leaves	Weight of uric acid in gm. excreted by		
	100 worms of 5th age (Spring)	1000 worms of 2nd age (August)	100 worms of 5th age (August)
Youngest leaves soon after sprouting	6.035	0.331	5.409
Younger leaves	2.514	0.230	1.907
Mature leaves	2.198	——	1.653
Old leaves	1.681	0.145	——
Youngest leaves with sugar added	4.443	——	3.804

TABLE 8

Relation Between Sericin and Fibroin Content of Silk Produced by Worms Fed on Leaves of Various Degrees of Maturity During the 5th Age.

Degree of Maturity of Leaf	Spring Worms		August Worms	
	Sericin	Fibroin	Sericin	Fibroin
Very young	28.38	71.62	26.45	73.55
Young	26.34	73.66	23.95	76.05
Mature	26.81	73.19	24.14	75.86
Old	27.62	72.88	24.85	75.15
Very young, plus sugar	26.77	73.23	24.14	75.86

Other investigators have arrived at principally the same conclusions as Kishi. Demjanovski and collaborators [11] for example found that top leaves are especially rich in proteins and phosphorus-containing compounds. A diet of top leaves (3–4 days old) reduced the larval period and led to strong and healthy worms which produced heavy cocoons of long and strong silk. Middle leaves (30–40 days old) had about the same effect as the average mixture of leaves. Bottom leaves (90–120 days old) on the other hand prolonged the larval stage, increased the mortality and led to a low yield of cocoons of inferior grade. These observations stand in good agreement with those made by Kishi [30] who investigated the protein content of leaves taken from various regions of the mulberry tree (see Table 9).

In case no other food is available silkworms will even consume very old, yellow leaves. Although the worms do not thrive on such a diet, they nevertheless derive sufficient nourishment from it to grow and even spin the cocoon (Ongara).[48] This observation is of special interest because it indicates that chlorophyll which is absent in the yellow leaves is not absolutely

necessary for the development of the worm. The differences in the composition of green and yellow leaves, based on data obtained by Ongaro, are shown in the last two columns of Table 3. As was to be expected, the nutritive value of diseased mulberry leaves is greatly decreased. As an example the composition of leaves infected by Diaspora (Pigorini),[52] is shown in column 7 of Table 3.

TABLE 9

The Protein Content of Leaves of Various Origin.

Type of leaves	% of protein of		
	Top leaves	Middle leaves	Bottom leaves
Spring leaves (average of 5 varieties)..	0.892	0.80	0.654
Summer leaves (average of 14 varieties)	0.983	0.988	0.833
Spring leaves from new branches.....	0.980	0.914	0.876

Effect of Light on the Nutritive Value of Mulberry Leaves

Since during the day and especially during direct exposure to sunshine a very active photosynthesis of organic compounds takes place in the mulberry leaves, it is to be expected that there exist marked differences between the chemical composition of leaves gathered at dusk and at dawn. Pigorini [51] and Sacchi [57] found that the organic matter increases considerably during daytime. This explains that leaves cut in the evening give the best sericultural results. Kishi [31] also observed that leaves which had been kept in the shade lose soluble carbohydrates, especially reducing sugars. Similar observations were made by Yoshimuru [68] and others who found not only a decrease of sugars in leaves protected from light, but also a decline of protein nitrogen, steroids and choline. Simultaneously, the non-protein nitrogen, especially the nitrate nitrogen showed a significant increase. A series of analyses of autumn leaves of various origin has been carried out by Di Maio.[13]

Effect of Wilting on the Nutritive Value of Mulberry Leaves

Withered leaves are not a suitable food for young silkworms. It is therefore of practical importance (Ikeda and Maruyama) [21] to know approximately the rate at which the various varieties of mulberry leaves wilt after having been cut off the tree. Lombardi [42] found that the loss of weight of unprotected leaves was from 22 to 50% in case of cultivated varieties and 52% for the wild mulberry leaf. In this connection it may be mentioned that there exists in China a race of silkworms which feeds on withered, spoiled or waste leaves, which have been rejected by other worms. The worms of this "beggar" race thrive rather well on this strange diet and produce a relatively good crop of silk, which is, however, of inferior quality (Sasaki).[59] But since these worms feed on material which is of no use anyway it has been found in certain localities of China to be quite economical to raise them along with other worms.

Effect of Fertilization and Storage, and the Nutritive Value of Mulberry Leaves

The nutritive value of the mulberry leaf is considerably affected by fertilization of the tree. Hiratuka [39] and Suda [62] for example have found that trees fertilized by nitrogen-containing materials produced leaves of high water, protein and nitrogen content. Worms which had been raised on such leaves were healthier and gave more silk than worms raised on leaves from trees growing on nitrogen-deficient soil. Proper working of the soil surrounding the trees also has a profound influence on the yield and nutritive value of leaves (Mannini).[43]

One of the principal interests of the sericulturist is to raise as many generations of silkworms as possible during the period of one year. One of the main obstacles on the road to solve this problem is the question of food supply. In order to be able to raise worms during the late fall and early spring it will be necessary to store leaves in such a manner as to preserve their nutritive value. Some pioneer work along these lines has already been done and more will probably be forthcoming in the near future. Landi [41] stored leaves which had been gathered during the summer for six months in an experimental silo. In the following spring the leaves were found to be well preserved but for a small top layer and served as a suitable food for silkworms. The composition of such ensilaged leaves is shown in column 6 of Table 3. Preliminary experiments on the influence of cold storage on mulberry leaves are being carried out among others by Pigorini [54] and Drigo.[14]

Some of the Constituents of Mulberry Leaves

Individual substances which have been isolated from the mulberry leaf include adenine, asparagine (Mimuroto),[44] cystine and cysteine (Kishi).[39] The last two substances are comparatively rare in very young leaves. They increase in proportion with the growth of the leaves and reach a maximum in such places where the photo-synthesis is most active. In older leaves the amount of the two substances undergoes a significant decrease. In every case the cysteine content is higher than the cystine content. Careful determinations of the tyrosine content of mulberry leaves have been carried out by Holtzmann. This author found that the intake of tyrosine in form of leaf proteins during the life history of the worm is sufficient to account for the high proportion of this amino acid in the silk produced as well as the tyrosine present in the chrysalis. The sterol content of mulberry leaves has been determined by Yoshida [67] who found it to be 0.4–0.07% in case of fresh and 0.16–0.20% in case of dried leaves. The chlorophyll content of the leaves is influenced by a great variety of factors such as type of tree and degree of illumination. (Ongaro).[49] A comprehensive report concerning the pigments of mulberry leaves has been published by Bergmann.[3]

The inorganic components of mulberry leaves have been investigated by Quajat and others. Quajat found that fall leaves contained considerably more inorganic materials than spring leaves (see Table 10). The aluminum content of leaves ranges from 0.16–0.68% depending on the type and age of the leaf. (Ongaro).[50]

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Donald Comer Appointed Director of Textile Foundation

Donald Comer, Chairman, Board of Directors, Avondale Mills, Sylacauga, Ala., and a resident of Birmingham, Ala., has accepted appointment by President Roosevelt as a Director of the Textile Foundation, to fill the unexpired term of Stuart W. Cramer of Cramerton, N. C., who died July 2, this year, and whose four-year term as director expires June 11, 1941. Those composing the present Board, in addition to Mr. Comer, are Franklin W. Hobbs of Boston, Mass., chairman; Frank D. Cheney, Manchester, Conn.; Harry L. Hopkins, Secretary of Commerce, and Henry A. Wallace, Secretary of Agriculture.

Abstracts

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I. Fibres (Synthetic and Natural) and Fibre Analysis

The Artificial Bleaching of Phormium Tenax (New Zealand Flax). J. S. Maclaurin. *N. Z. J. of Science and Tech.*, March 1940, V. 21, P. 263B.

A thorough washing of the fibre with water followed by treatment with potassium permanganate gave an improvement in color, sufficient, in the author's opinion, to warrant its adoption on a commercial scale. An estimate of the cost of the chemicals used per ton of fibre treated is given. (C)

Casein Fibres: Spinning. *Klepzig's Textil.-Z.*, 1940, V. 43, P. 246–248; abs. *J. T. I.*, May 1940, V. 31, P. A235.

A general account is given of the properties of casein, the difference between casein and wool protein, and the preparation and spinning of casein solutions, and patent literature relating to the production of casein fibres is briefly reviewed. (C)

Chemical Investigations on the Fleece of the Sheep. Martin R. Freney. *Australia Council Sci. Ind. Research, Bull. No. 130*, 52 pp. (1940); abs. *C. A.*, 1940, V. 34, Vol. 4276; *J. T. I.*, June 1940, V. 31, P. A297.

The variations which may occur in the fleece as a result of physiol. and nutritional changes with respect to the sheep are discussed. Special attention is given to the variability of the S in the fibre. Wool wax is almost

neutral on secretion and appears to be somewhat unsatd. having an I value of 30 to 40. After secretion it is shown to be oxidized; this may account for its content of O acids. The suint contains about 20% of a mixt. of K soaps of fatty acids ranging from valeric to palmitic acids. In addn., it contains lactic, hippuric and succinic acids, urea, lanaurin and other N-contg. compds. The fleece also contains small amts. of finely divided protein material which may be derived from epithelial debris, the inner root sheath, and from weathered tips of wool fibres. Various methods for estg. the fleece constituents are reviewed and compared. (C)

METHYLATION OF COTTON FIBRE WITH ETHEREAL DIAZOMETHANE. Richard E. Reeves and H. Jeanne Thompson. *Contrib. Boyce Thompson Inst.*, V. 11, P. 55–9 (1939); abs. *C. A.*, 1940, V. 34, Col. 3923.

Starting with raw cotton, repeated treatment with diazomethane gives a product contg. 9.8% methoxyl; mercerized cotton takes up 17.7% methoxyl. Completely methylated cellulose contains 45.6% methoxyl. The products retain the original fibre form, do not disperse in NaOH, but disperse readily in cuprammonium hydroxide soln. Optical rotations of the dispersions decrease with increase in methoxyl; methylated fibres show resistance toward bacteria; the diffraction pattern differs from that of a compound contg. methoxyl introduced by another method. Increase of moisture increases methylation of raw and mercerized fibre. (C)

SOME EFFECTS OF ALKALINE REAGENTS ON WOOL. I. Chemical studies with special reference to felting and shrinkage. M. R. Freney and M. Lipson. *Australia Council Sci. Ind. Research, Pamphlet No. 94*, P. 7–24 (1940); cf. *C. A.*, 1940, V. 34, Col. 2181; abs. *C. A.*, V. 34, Col. 4276.

The effects of various concns. of NaOH and KOH in H_2O, CH_3OH, C_2H_5OH, C_6H_6, turpentine and kerosene on the phys. and chem. properties of wool were studied, special attention being given to the felting characteristics of the fibre. It was found that immersion of wool for 1 to 2 min. in a 7% soln. of KOH in C_2H_5OH reduced the felting tendency of the fibre. Special care is necessary in neutralizing the alkali, as dil. solns. of KOH are harmful to wool. Wool treated by this process becomes slightly less bright, has a "handle" which compares favorably with that of other "unshrinkable" wools, dyes satisfactorily, and has an increased affinity for acid dyes. Its scale structure does not appear to be different from that of normal fibres and the S and N contents are unaltered by the treatment.

II. PRELIMINARY NOTES ON THE PHYSICAL PROPERTIES OF ALKALI-TREATED WOOLS. E. H. Mercer and M. R. Freney. *Ibid.*, P. 25–8.

Individual fibres are not weakened by the treatment, and treated yarns exhibit a higher breaking strength, more extensibility and increased resistance to an oscillating stress than untreated yarns. Over-treatment of wool caused discoloration and damage. (C)

TEXTILE FIBRES, OLD AND NEW. Wm. H. Cady. *Am. Dye. Rptr.*, April 15, 1940, P. 189–97.

Paper presented at March 1, 1940 meeting, New York Section, A. A. T. C. C. (C)

WASTE SILK: FERMENTATION DEGUMMING OF. V. USEFUL THERMOPHILIC BACTERIA FOR FERMENTATION DEGUMMING. Hideo Katagiri and Tosio Nakahama. *J. Agr. Chem. Soc. Japan*, V. 15, P. 1042–4; *Bull. Agr. Chem. Soc. Japan*, V. 15, P. 144 (in English) (1939); abs. in *C. A.*, 1940, V. 34, Col. 1492.

Twelve strains of thermophilic bacteria were isolated from the degumming liquid at 55°. An aerobic bacillus having a strong degumming action for raw silk was discovered. It may belong to *Bacillus robustus* Blau. Degummase was easily dissolved out into the culture soln. after fermentation for 5 days. Cf. *C. A.*, V. 32, Col. 7272. (C)

WOOL: FINE STRUCTURE OF. III. SWELLING TESTS ON CRIMPED WOOL. K. Ohara. *Mell. Textilber.*, 1940, V. 21, P. 1–3.

Samples of 70s Australian merino wool ("hungry") were treated on a microscope slide with acids, neutral salts and alkalies. In every case swelling took place on the outer curvature of the crimp. This is illustrated by photomicrographs in ordinary light and using crossed nicols. (C)

II. YARNS AND FABRICS

CELLULOSE ACETATE RAYON WARPS: DEVELOPMENTS IN PROCESSING. K. W. Zachrich. *Zellwolle, Kunstseide, Seide*, 1939, V. 44, 397–399; abs. in *J. T. I.*, April 1940, P. A181.

The increasing use of cellulose acetate rayon is pointed out and developments in processing, such as the use of larger packages, especially conical cheeses, the application of warp sizing methods, and the use of water-soluble sizes, are discussed. Warp sizing equipment is briefly discussed, the requirements of a size for the warp sizing of cellulose acetate rayon are outlined and suitable products are mentioned, and the advantages of the use of conical cheeses are described. (C)

CLIMATIC EXPOSURE ON TEXTILE FIBRES AND FABRICS: EFFECT OF. A. C. Thaysen, H. J. Bunker, K. R. Butlin and L. H. Williams. *Ann. Applied Biol.*, 1939, V. 26, P. 750–81; abs. in *C. A.*, 1940, V. 34, Col. 2180.

Fabrics were exposed to bacterial attack under a variety of climatic conditions. Exposure of cellulose fibres in sun and shade caused a lowering of viscosity; but from soil exposure, with more extensive microbiol. destruction, there was no effect on viscosity. Viscosity measurements on Indian, Egyptian and American cotton are shown in graphs. All sun- and shade-exposed fabrics, including silk and wool, increased in acidity during the first three months of exposure but showed little increase on further exposure. In microbiologically active soil, cellulose acetate rayon was completely resistant while cellulose, wool, silk and cellulose rayon fabrics disintegrated. (C)

DRYING OF TEXTILES: THEORY AND PRACTICE OF. Martin Berg. *Spinner u. Weber*, 1939, V. 57, No. 41, P. 6–8; No. 42, P. 4, 6; No. 43, P. 42–6; abs. in *C. A.*, 1940, V. 34, Col. 1495. (C)

THE DUERST METHOD OF FIGURING PROGRESSIVE YARN TWIST. *Cotton*, December 1939, V. 103, P. 64–6.

The formula developed by John Duerst, Research Engineer, Clark Thread Co., Clarkdale, Ga. This is given as the Duerst method of calculating pro-

gressive twists for spinning as presented here. Progressive twists have been in use in many European mills for years, and mill men in this country have used them, usually arriving at the proper multiple by the hit or miss method, which, though worthwhile once the correct multiple is determined, has proven costly. Mill men know that to insert more twist than necessary is expensive, and to insert fewer turns than necessary is disastrous. By following this article closely it may be possible to make savings in your plant, but the method is not given as a procedure to be instituted immediately.

$$\frac{\sqrt{1 + 8 \times \text{counts}} - 1}{2}$$

For those not so mathematically inclined, Mr. Duerst has simplified the use of this formula by preparing tables of all counts from 1s to 100s, with the corresponding twist multiple to be used in arriving at the final progressive twist multiple. (C)

FUNORI: A NEW SIZING AGENT FOR RAYON. S. H. Kotak. *Indian Text. J.*, 1940, V. 50, P. 119.

Funori is a kind of seaweed growing in Japan and in Korea. It is dark pink in color and so must be bleached for use with textiles. $NaHSO_3$ is used and the bleached funori is then spread on a long wooden plank and sprinkled with hot water. It sticks together and is shipped in sheet form. Its compn. is: water 12.3, alginic acid 61.0, cellulose 26.0 and ash 0.7%. Advantages claimed for funori are: (1) increased elongation, pliability and strength of the sized rayon warp, (2) its neutral reaction rendering the addn. of alk. substances unnecessary, (3) no necessity for a desizing agent, (4) funori is not brittle in dry form, (5) the soln. does not putrefy even if stocked for several days and (6) the binding power of funori is less than that of starch but the viscosity is higher and less is needed, and (7) its emulsifying properties are good. (C)

HIGH-SPEED PRINTING. *Text. Wld.*, February 1940, V. 90, P. 122–3.

New process developed at Clearwater Mfg. Co. by the late M. N. Bulford. It consists basically of a printing machine equipped with a special ball-bearing water-cooled cylinder, a scray which feeds the fabric in such a manner that the rolls of cloth can be changed without stopping the machine, and a tenter frame which straightens and delivers the cloth to the printing machine at high speeds. The mechanical arrangement is such that the cloth is fed directly onto the blanket without use of a backgray. Following several months of successful operation of a two-color experimental machine, an eight-color machine embodying the same principles has been constructed and set up at Clearwater, where it is now in operation. Indicative of the speed of the process is the fact that the two-color machine recently averaged 6,200 yd. per hr. for 18 hr. on shirtings, as compared with a possible average of 3,300 yd. per hr. for the same goods on a conventional machine. This represents a gain of almost 100%. However, it must be remembered that the speeds vary somewhat with the type of goods being run. Possibly even more important than the increased speed of operation is the fact that the machine does not have to be stopped in order to change rolls of cloth. An average run without stopping for this purpose is said to be 30,000 yd. per 8-hr. shift. (C)

How Long is One-Inch Cotton? E. H. Helliwell. *Cotton, February* 1940, Vol. 104, P. 106–110.

A discussion of the difference between classified length and average length of cotton, which latter the author uses. He shows that there is a definite relation between them after allowance for abnormalities. He uses a mechanical type of staple sorter that makes a record of the fibre diagram on paper ribbon contained in a roll, and this diagram is marked with a proportional divider into 5% divisions, also indicating the correct point for measuring the classified length of normal cotton. He also shows how data on the relation of average fibre length to yarn strength may be compiled. (C)

Jacquard Fabrics: Changing Density in Weaving. H. Pflanzer. *Zellwolle, Kunstseide, Seide,* 1939, V. 44, P. 434–5; abs. in *J. T. I.,* April 1940, P. A183.

The possibility is discussed of producing in Jacquard weaving with the same cards, harnesses and looms staple fibre fabrics showing the same designs but having different thread densities. Fabrics of lower densities than those for which the cards and harness were originally designed are obtained by leaving certain healds empty. The best methods of distributing the empty healds are illustrated by a study of examples. (C)

Lanital, Artificial Wool, Derived from the Casein of Milk: Manufacture and Properties of. Lo Duca. *Génie civil,* 1939, V. 115, P. 317–20; abs. in *C. A.,* 1940, V. 34, Col. 2180.

Recent improvements in Ferretti's method as carried out in Italy are discussed. The toughness and elasticity of lanital have been greatly increased. Chem. and microscopic tests for distinguishing between natural wool and lanital are given. Production in Italy has fallen off about 50% since 1938 owing to lack of milk. (C)

Northrop Rapier Shuttleless Automatic Loom. British Northrop Loom Co., Ltd. *Textile Weekly,* 1940, V. 25, P. 197–200; *Textile Mercury and Argus,* 1940, V. 102, P. 154–5; *Textil Mfr.,* 1940, V. 66, P. 61–2; abs. in *J. T. I.,* April 1940, P. A182.

Descriptive of the Northrop rapier loom for the woolen and worsted trades which will insert at will single picks of weft from one up to seven colors or qualities into a fabric by means of "rapiers" instead of shuttles. The loom is shuttleless and automatic and draws its supply of weft from cones. (C)

Sizing of Cotton Warps: Defects in—and their Elimination. Th. Schinkl. *Spinner u. Weber,* 1939, V. 57, No. 43, P. 41–2; abs. in *C. A.,* 1940, V. 34, Col. 1493.

Breaking of the threads because of low moisture contents is avoided by the use of synthetic fats; excessively high concn. of the size with subsequent undesirable after effects is counterbalanced by the addn. of "Aktivin" and Na perborate. Various other defects are discussed with suitable remedies. (C)

SPINNING RAYON ON FLAX MACHINERY. *Irish Text. J.*, 1939, V. 5, No. 8, P. 2; abs. in *J. T. I.*, Oct. 1939, P. A621.

Linen-like rayons have recently been produced in Germany, having coarse individual filaments which show variations in titre or have been given a surface parchmentizing treatment. Yarns resembling linen yarns can be obtained by spinning staple fibre of linen-like staple on flax spinning machinery. The spinning of mixtures of staple fibre and linen fibres is not always satisfactory and it is generally preferable to mix the two types of yarn in fabrics rather than to use mixture yarns. (C)

STAPLE FIBRE-COTTON MIXTURES: MERCERIZATION. H. J. Henk. *Kunstseide u. Zellwolle*, 1939, V. 21, P. 383; abs. in *J. T. I.*, Mar. 1940, P. A139.

The alkali-sensitivity of staple fibre and staple fibre-cotton materials is considered, particularly in relation to the tendering caused by "strong" alkali liquors in mercerizing and to the intensification of such damage by subsequent washing. The "degrees of hydration" of the alkali metals (Li 120, Na 66, K 16, Rb 14, Cs 13) reflect the swelling capacity of the various alkali liquors. Maximum swelling of staple fibre in caustic soda occurs at a concentration of 15° Bé (KOH, 25° Bé) and at 19° C. certain staple fibres undergo a weight loss of as much as 14.5% which is reduced to 7.5% by the addition of common salt to the extent of 50 gm. per litre. Washing subsequent to mercerization with caustic potash solution produces less damage (the solubility of oxy- and hydro-cellulose in KOH is smaller) and a better handle. It is recommended that caustic potash should be used for mercerizing when caustic soda gives the material a bad handle, and that in mercerizing with caustic soda a concentration of less than 10° Bé should be used. (C)

STAPLE FIBRE: OILING, SCOURING, BLEACHING, MERCERIZING AND SIZING. *Leipz. Monats. Text. Ind.*, 1939, V. 54, Fachheft III, P. 73–6; abs. in *J. T. I.*, Feb. 1940, P. A80.

Modern methods and equipment for the oiling of staple fibre are discussed, and procedures for the scouring, bleaching, mercerizing and sizing of goods composed of mixtures of staple fibre with cotton or wool are briefly described. (C)

STAPLE FIBRE YARNS: BREAKING LENGTH. H. Köb. *Kleipzig's Textil-Z.*, 1939, V. 42, P. 634–7; abs. in *J. T. I.*, Feb. 1940, P. A100.

The breaking length of a yarn is given by the relation $R_{km} = P.N_m/1000$, where P is the breaking load in grams and N_m the metric count. When cotton or staple fibre yarns are prepared from a given sample of fibre it is found that the breaking length decreases with increasing fineness. Data for staple fibre yarns produced by the cotton process are given and it is estimated that the average decrease in breaking length for an increase of 10 in the metric count is 0.5 km. for the ordinary type of staple fibre studied. The breaking length has been used as a basis for the comparison of yarns. The use of the breaking length for $N_m = 50$ as standard is recommended. For comparing yarns of different counts the breaking length should then be corrected according to the formula $R_v = R + k(N_m - 50)$, k being 0.05 for the examples studied, and R_v the corrected breaking length for comparison purposes. The qualities of yarns

can then be compared by comparing the corrected breaking lengths. The substance efficiency, given by the relation (R_{km} yarn/R_{km} fibre)100, has been used as a measure of technical spinning value. In this relation also the value of R_{km} yarn corresponding to $N_m = 50$ should be used. The influence of twist on breaking length is discussed and it is shown that the correction to be applied for twist cannot be determined in the same way for staple fibre yarns as for cotton yarns. (C)

TEXTILE MILDEWS, THEIR PREVENTION AND CONTROL. Eric Hardy. *Canadian Text. J.*, 1939, V. 56, No. 23, P. 34.

The occurrence of mildew in yarn or cloth is encouraged by farinaceous sizes, excessive alk. treatment, strong chlorination and nitrogenous decompn. of wool under harsh treatment. Cellulose provides nutrient for certain fungi, while silk gum and raw cotton contain enough albumin for others. An *Aspergillus* mold can grow in an acid condition after wool has been dyed. Phenols and dibromophenol destroy molds but their odors are irritating. Formalin is good except on gelatin sizes. Borax and salicylic acid are useful on all sizes. Hygroscopic $ZnCl_2$ maintains the elasticity of the fibre, but unless it is washed out from the cloth before singeing there may be some tendering of the fabric. Na_2SiF_6 in amts. of 1 part per 400 parts of fabric by wt. provides complete immunization. The non-toxic higher tertiary-alkyl phenol and salicylanilides are improved agents for this purpose. (C)

THIS ANTI-SHRINK BUSINESS—"CHEMICAL OR MECHANICAL . . . WHICH IS BETTER?" A. Tsimehc. *Silk J. & Rayon Wld.*, December 1939, P. 25–32. (C)

WASHING OF WOOL: USE OF FAT SOLVENTS IN. A. Foulon. *Monatschr. Textil-Ind.*, 1939, V. 54, P. 247–8; abs. in *C. A.*, 1940, V. 34, Col. 1492.

The best com. product recommended by F. for this purpose is Sulfinol L. Its use is discussed in detail. (C)

WEAVING COVERED-RUBBER YARN. Charles E. Bergamini. *Text. Wld.*, March 1940, V. 90, P. 58.

Gives routine tests for maximum stretch which warn overseer when to make tension change. (C)

III. CHEMICAL AND OTHER PROCESSING (NOT OTHERWISE CLASSIFIED)

CATALYTIC DAMAGE TO BLEACH (FOR TEXTILES). G. Dierkes. *Klepzig's Textil-Z.*, 1940, V. 43, P. 46–50; abs. in *C. A.*, 1940, V. 34, Col. 1855.

Ferrous and ferric iron in water cause decompn. of peroxide liquors, the rate of which increases with increasing alky. The catalysis can be repressed and the evolution of O can be regulated by the use of stabilizers. Hard waters low in Fe are suitable without treatment for the peroxide bleaching process. (C)

CELLULOSE ACETATE PRINTING. "Technicus." *Silk J. & Rayon Wld.*, November 1939, P. 18–19.

Discusses the preparation of cellulose acetate colors. (C)

CHLORINATION OF WOOL. Hans J. Henk. *Deut. Wollen-Gewerbe*, 1939, V. 71, P. 1129, 1132; abs. in *C. A.*, 1940, V. 34, Col. 1492.

The chem. reactions taking place during the chlorination are reviewed and disadvantages of chlorinating with HClO are discussed. Bromination is less harmful to wool than chlorination but is not generally applicable, owing to the cost of Br. The bromoamines formed during bromination are more stable than the corresponding Cl compds. Brominated wool is softer than chlorinated wool and its soly. in dil. acids, alkalies and salt solns. is lower. Shrinking is minimized to the same extent with both halogens. The use of halogens can be avoided entirely by pptn. of $Al(OH)_3$, TiO_2 or gelatin tannate in the fibre or by treatment with HCHO, CH_2CHO or acrolein. However, these treatments have not yet been developed satisfactorily for use on a com. scale. (C)

CONTINUOUS DYEING OF WOOL AND HALF-WOOL: METHOD BASED ON THEORY OF TURGESCENCE. E. Justin-Mueller. *Teintex*, 1939, V. 4, P. 656–9; abs. in *C. A.*, 1940, V. 34, Col. 2178.

Important factors considered are: (1) the fabric must be clean and dry and the dye bath kept at 80°, 90° or 95° depending on the dye used, (2) the conen. of the dye bath must be such as to give the max. desired intensity in 20 sec., (3) the dye must be well dissolved, (4) in a mixt. of dyes all must have the same solv., (5) on entering the dye bath, the dry cloth must be completely wetted. A schematic drawing of the continuous process is included. (C)

DECOMPOSITION OF HYPOSULFITE AND RONGALITE: PRODUCTS OF—UNDER CONDITIONS OF THEIR USE IN COTTON MILLS. B. V. Ponomarenko and Yu. I. Mirtova. *Khlopchato-Bumazhnaya Prom.*, 1939, No. 1, P. 37–9; abs. in *C. A.*, 1940, V. 34, Col. 1494.

Decompn. of hyposulfite is accompanied by the evolution of SO_2 and starts at ordinary temp. and increases with rising temp. Rongalite is more stable at ordinary temp. and shows its reducing properties at 70°, giving off volatile products. Upon acidification it gives off H_2S and HCHO, while in alk. soln. it is more stable and decomps. only at high temps. (C)

DYED TEXTILES: ACTION OF LIGHT. A. Seyewetz. *Rev. gen. Mat. Color.*, 1940, V. 44, P. 1–4, 45–6; abs. in *J. T. I.*, April 1940, P. A190.

A broad review is given of the destruction of dyes by light and the nature of the photochemical reactions produced by ultra-violet radiation. Reference is made to the production of colored products from diazo-sulphites, and tri-phenylmethane leuco bases. Examples are quoted of the contrary behavior of apparently similar systems to demonstrate the complexity of the subject. (C)

DYEING OF STAPLE RAYON AND STAPLE RAYON MIXTURES: PRACTICE OF THE. Wm. Kegel. *Deut. Textilwirt.*, 1939, V. 6, No. 21, P. 29; abs. in *C. A.*, 1940, V. 34, Col. 1489.

As it is necessary to know what grade of staple rayon is present in a given product previous to dyeing operations methods for making such detns. are explained. (C)

DYEING OF TEXTILES: EQUALIZING AND PENETRATION IN THE. G. Schwen. *Mell. Textilber.*, 1940, V. 21, P. 17–28.

Improper prepn. of the goods is inimical to even dyeing as is shown by colored pictures illustrating dyeing defects caused by the local action (1) of alkali, acid, light and pptd. lime soaps on wool and (2) of uneven bucking, acids and oxidation agents (bleaches) on cotton and (3) of oil residues on rayon. Other colored pictures show the beneficial effects, on evenness of dyeing, of various procedures, including use of agents to prevent the dyestuff being taken up too rapidly by the fibre. The latter agents are (a) those having affinity for the fibre (*e.g.*, Igepon T or Gardinol with wool) and (b) those having affinity for the dyestuff (*e.g.*, certain highly oxygenated compds. such as Palatine Fast Salt O with Palatine Fast Blue GGN or Peregal O with Chicago Blue 6B). (C)

FADING OF DYED TEXTILES BY RADIANT ENERGY. M. Luckiesh and A. H. Taylor. *Illum. Eng.*, 1940, V. 35, P. 169–72; abs. in *C. A.*, 1940, V. 34, Col. 2607.

Forty specimens of dyed cotton, wool and silk of grades 0 to 4 (appreciable fading in sunlight after 6, 12, 24, 48 and 96 hrs.) were exposed to fluorescent "daylight" lamps and to 75-watt W lamps. In general, W lamps cause more rapid fading of blue, violet and purple specimens; and the fluorescent lamps, slightly more rapid fading of pink, yellow, orange and red specimens, regardless of whether the cloth is cotton, wool or silk. No dyed synthetic textiles were tested. Expts. are still in progress. (C)

IV. RESEARCH METHODS AND APPARATUS

A SIMPLE MICRO-TEST FOR COPPER. E. Heyman and L. F. Kerley. *Analyst*, July 1939, V. 64, P. 502–3; abs. in *Eastman Kodak Abs. Bull.*, April 1940, P. 215.

The authors found that aleic acid develops a green color in contact with solutions containing traces of copper. (S)

DYES: REMOVAL OF—FROM TEXTILES BY RUBBING. Olgerts Ripa. *Acta Univ. Latviensis, Kim. Fakultat.*, 1939, Ser. 4, No. 12 (in Lettish, P. 455–68; in English, P. 469–71); abs. in *C. A.*, 1940, V. 34, Col. 1854.

A dyed textile 4 × 25 cm. was fastened about a wooden pulley. Tangent to the pulley was a wooden lever wrapped with a white fabric which accumulated the dye from the rubbing. After 100 revolutions the dye adhering to the white fabric was evaluated with a Pulfrich photometer. Tables give the dye rubbed off in relation to speed of rotation, pressure, no. of revolutions, size of rubbing surfaces, and size of dye particles. (C)

EXAMINATION OF TEXTILE FIBRES IN FINISHING PLANTS: SIMPLE SCHEME FOR THE. W. Schönberger. *Klepzig's Textil-Z.*, 1939, V. 42, P. 751–4; abs. in *C. A.*, 1940, V. 34, Col. 1490.

Test methods for identification of fibres in dyed and finished textiles. (C)

LANITAL: NOTE ON ITS DETERMINATION IN WOOL MIXTURES. Eliseo T. Huergo. *Ind. y. quim.*, 1939, V. 2, P. 177–81; abs. in *C. A.*, 1940, V. 34, Col. 2181.

The method proposed for a detn. of the lanital content of wool mixts. is based on the fact that wool contains only traces of P, while lanital, being

a casein, contains considerable fixed amts. of P. An analysis of the ashes of a burned sample, yielding their content of P_2O_5, therefore throws light on the compn. of the sample. The advantages of this method over those used heretofore are pointed out in conclusion. 7 references. (C)

MERINO FLEECE: METHODS FOR DETERMINING LENGTH IN THE. V. Bosman and M. L. Botha. *Onderstepoort J.*, 1939, V. 12, P. 261–72; abs. in *J. T. I.*, Jan. 1940, P. A48.

Methods for determining staple and fibre length in the merino fleece are outlined. There is no significant difference in staple length between the two sides of the fleece. For sampling from the live animal, a selection of six measurements gives a reliable mean staple length for the fleece. The shorn fleece is demarcated by a frame (similar to that used by other workers) into ten equal regions and a sample from each region extracted for measurement. (C)

MORDANTS: INVESTIGATION OF—ON FIBRES AS A MEANS OF IDENTIFYING THE DYES USED. P. Baffroy. *Teintex*, 1940, V. 5, P. 9–14; abs. in *C. A.*, 1940, V. 34, Col. 2606.

Animal fibres are burned and then heated with HNO_3 or NH_4NO_3 to complete the oxidation. A white residue indicates presence of Al, Ca, Sn, Sb, Si, Ba, clay, W or Ti. A brown or yellow-brown ash shows the presence of Fe alone or mixed with some white ash. A brown or brown-black residue indicates Cu, Mn, Ni, Co or Cr. A gray-green ash indicates Cr. Methods of testing for these elements are included. (C)

NEW COLOR MEASURING DEVICES. C. H. S. Tupholme. *Text. Col.*, August 1939, P. 538. (C)

pH CONTROL: SNARES OF. E. Kornreich. *Dyer*, 1939, V. 82, P. 359–60; abs. in *C. A.*, 1940, V. 34, Col. 2183.

In textile processing, not only pH, but also other circumstances must be considered; *e.g.*, the titration alky. or acidity, the influence of the treated fibre, and the method of procedure. (C)

PHOTOGRAPHIC NEGATIVE MATERIAL AND LIGHT FILTERS FOR PHOTOMICROGRAPHY. H. Schöpf. *Phot. Korr.*, Jan. 1939, V. 75, P. 8, 9–14, 15; abs. in *Eastman Kodak Abs. Bull.*, Dec. 1939, P. 641. (8)

QUALITY CONTROL IN A WOOLEN MILL. Werner von Bergen. *Am. Dye. Rptr.*, Feb. 19, 1940, P. 84–92.

The author, who is research director for the Forstmann Woolen Co., Passaic, N. J., presented this paper at recent meetings of the New York and Philadelphia Sections of the A. A. T. C. C. After noting that prior to 1914 very few woolen and worsted mills had laboratories and giving names of some of the pioneers, he describes in much detail a tour through the Forstmann laboratory—the apparatus, the test methods, and the standards that are the objectives of control work. In conclusion he named the following as the most important tests for control of Forstmann cloth quality: the determination of the shrinkage, fat size, and acid content, control of the light fastness, the moisture determination, controlling of count, twist, strength, abrasion, and the scientific grading of the wool. It is one of the most informative papers on this subject that has ever been published. (C)

RAYON AND STAPLE FIBRE: THE R–O–X METHOD FOR THE MICROSCOPIC SURFACE EXAMINATION OF. *Silk J. & Rayon Wld.*, 1939, October, V. 16, P. 16–7; November, V. 16, P. 20–1; December, V. 16, P. 27–8; 1940, January, V. 16, P. 30–3.

The R–O–X method is a special embedding method for spun fibres. In contrast to all embedding methods known to the present, in which the fibre is entirely enclosed in fluid, the R–O–X method arranges the fibres to be examined on one side only, under optical illumination from the rear; that is to say, the half of the fibre turned away from the microscopic objective is immersed in a special embedding medium called R–O–X. R–O–X is a thick viscous fluid, the refractive power of which, after evaporation of the solvent medium, should approach as near as possible that of the fibre to be examined. The wool fibre, for instance, possesses a refractive index of $D_{D_{20}}$ 1.555, viscose fibre one of $n_{D_{20}}$ 1.547–1.549. For this reason, various brands of R–O–X have been introduced for different fibres. For woolen fibres an R–O–X with a specific refractive index of 1.540—1.560 is best; for viscose yarns one with $n_{D_{20}}$ 1.545 to 1.550 relative to the solid substance. (C)

RAYON-YARN TENSION ADJUSTMENTS. C. Stanley Marshall. *Text. Wld.*, Jan. 1940, P. 75.

Method for testing differing frictional resistances of yarns of various types. (C)

V. PURE SCIENCE, ECONOMICS AND MISC.

AMINO ACIDS: SEPARATION. R. L. M. Synge. *Biochem. J.*, 1939, V. 33, P. 1913–17, 1918–23, 1924–30, 1931–4; abs. in *J. T. I.*, April 1940, P. A216. (C)

CELLULOSE: ATTACK BY MICRO-ORGANISMS. H. Staudinger, M. Staudinger and H. Schmidt. *Zellwolle, Kunstseide, Seide*, 1940, V. 45, P. 2–4; abs. in *J. T. I.*, April 1940, P. A223.

Tests on cotton yarn showed that a loss in strength occurred when the yarn was exposed to the action of cellulose-destroying bacteria by immersion in water. Determinations of the degree of polymerisation of the cellulose of the original and treated samples and of a used fishing net, and also of nitrated products obtained from them, showed that the decrease in strength was not due to any appreciable decrease in degree of polymerisation. Photomicrographs of the fibres show a corrosion effect as a result of attack by bacteria. The injured fibres do not give the usual bead effect on swelling in cuprammonium. Photomicrographs of cotton, ramie, staple fibre and Cuprama fibres after immersion in sump water are given and compared. It is suggested that the decomposition of cellulose by bacteria proceeds from the end groups of the molecule whereas attack of cellulose by fungi results in a splitting of the molecule in the middle. (C)

CELLULOSE: REFRACTIVE INDEX AND DEGREE OF SWELLING. P. H. Hermans and P. Platzek. *Rec. Trav. Chim.*, 1939, V. 58, P. 1001–7; abs. in *J. T. I.*, Jan. 1940, P. A47.

The refractive indices of regenerated cellulose filaments with moisture contents ranging from 0 to 76.6% have been measured by the Becke line method in suitable immersion media. As reported by Meyer and Frey-Wyssling for ramie, the lowering of the index with increase of water con-

tent is much smaller than that given by the application of the linear or the Wiener n^2 rule to a mere mixture of cellulose and water, until the moisture content reaches about 50%, when the observed and calculated values agree. (C)

COPPER AND MANGANESE: DETERMINATION. G. F. Palfrey, R. H. Hobert, A. F. Benning and I. W. Dobratz. *Ind. Eng. Chem., Anal., Edn.*, 1940, V. 12, P. 94–6.

Methods for the determination of small amounts of copper and manganese in dyes, rubber chemicals and rubber are described in detail. The organic matter is first destroyed by wet oxidation with sulphuric and nitric acids followed, when necessary, by hydrogen peroxide. Copper is then determined colorimetrically, with sodium di-ethyldithiocarbamate as indicator. Manganese is determined by oxidation to permanganate. Both elements can be determined in the presence of Fe, Pb, Zn, Ba, Al, and small amounts of Cd, and in the presence of each other. The methods may be applied to other materials such as fabrics, pigments and inorganic chemicals, provided other metals are not present in interfering amounts. The accuracy of both methods is about $\pm$ 5% of the amount of metal present. (C)

CHEMICAL PRECIPITATION OF TEXTILE WASTES AND STUDIES OF pH CONTROL. Ralph Porges, Robert K. Horton, and Herman G. Baity. *Sewage Works J.*, 1939, V. 11, P. 828–63.

The optimum pptn. of Sulfur Black waste appears dependent on mixing, flocculation and addn. of chemicals. Addn. of iron salts prior to acids reduces odors and favors better color removal owing to the formation of insol. Fe sulfide. By the addn. of inert materials such as coal, dust or sand more complete settling is obtained. For the treatment of kier liquors alum alone or alum and acid produce the best results. Cu and lime yield fair results. Carbonation by CO_2 and coagulation with $CaCl_2$ produces a poor effluent but offers possibilities as a cheap method for partial treatment. The best color removal for indigo waste liquor is obtained with lime, second best with alum and third best with $CaCl_2$. The most economical treatment is a combination of lime and copperas followed by flocculation. The resulting sludge dewaters rapidly. The most satisfactory treatments of vat dye waste were $FeCl_3$, alum, copperas in combination with lime and $Fe_2(SO_4)_3$. In the treatment of developed color waste the best and most economical results were obtained from copperas and lime. Naphthol color dye waste was successfully treated with H_2SO_4, $Fe_2(SO_4)_3$, alum and $FeCl_3$. Aniline black wash water was treated successfully with lime and alum. In general, results show that each coagulant appears to have a pH zone for optimum pptn., this zone being independent of the individual waste being treated. (C)

COLOR OF DYES: THEORY OF THE. Linus Pauling. *Proc. Natl. Acad. Sci. U. S.*, 1939, V. 25, P. 577–82; abs. in *C. A.*, 1940, V. 34, Col. 887. (C)

DEFECTS IN TEXTILES: CAN AIR BE THE CAUSE OF. Rudolf Schwarz. *Deut. Textilwirt*, 1939, V. 6, No. 14, P. 20–3; abs. in *C. A.*, 1940, V. 34, Col. 1184.

Damages caused by the atm. are described and suitable air conditioning installations are discussed and shown. (C)

DEGRADATION OF ORIENTED CELLULOSE STRUCTURES BY POLARIZED ULTRA-VIOLET LIGHT. C. W. Mason and F. B. Rosevear. *J. Am. Chem. Soc.*, 1939, V. 61, P. 2995–3001.

Although some reported experiments may have been complicated by effects other than that of light, a certain portion of the ultra-violet region does appear to produce physico-chemical changes in the cellulose structure. Parallel ramie fibres have now been irradiated, in a cell containing metallic sodium so as to eliminate air or moisture and consequent secondary, non-directional reactions, with polarized ultra-violet light obtained by using a silica "pile of plates" polarizer. Degradation of the fibre was about 25% greater when the light vibrated across the fibres instead of lengthwise. From analogy with simpler compounds, it is concluded that photochemical degradation of cellulose chains is greatest when they are oriented so that the light energy vibrates in the direction in which they are most deformable. (C)

ENZYME PREPARATIONS: PRODUCTION AND APPLICATION. L. Wallerstein. *Ind. Eng. Chem.*, 1939, V. 31, P. 1218–24.

The author gives a general survey of the commercial production and application of enzymes. The manufacture of citric acid from sugar by fermentation with *Aspergillus niger* is cited as an example of the industrial importance of the subject. The enzyme preparations, from micro-organisms, chiefly used industrially are: α- and β- amylases from *Aspergillus oryzae*, amylase and protease from *B. subtilis* and invertase from yeast. The general production, purification and testing of these are described and their use in the food, paper, photography, leather and textile industries (sizing, desizing, silk soaking and degumming) are outlined. It is stated in connection with the sizing of cotton and rayon that: "Raw starches are seldom used since they lack penetrating value; and it is now common practice to liquefy raw starch suspensions with amylases. . . ." (C)

FIBRE-FOLLICLE TERMINOLOGY IN THE MAMMALIA. A. B. Wildman and H. B. Carter. *Nature*, 1939, V. 144, P. 783–4; abs. in *J. T. I.*, Jan. 1940, P. A2.

The present confusion in fibre-follicle nomenclature is indicated and a new terminology is suggested. This recognizes clearly the two main growth phases: (1) the phase leading to the formation of the trio group (primary follicles), and (2) the succeeding or post-trio phase (secondary follicles). This new terminology should make possible a more intelligible co-ordination of research on the development of the mammalian coat, and more especially the development of the sheep's fleece. A table shows the proposed new terminology in relation to the old. (C)

FIBROUS HEAT INSULATING MATERIALS: APPLICATION. J. L. Finck. *Ind. Eng. Chem.*, 1939, V. 31, P. 824–7.

The mechanism of heat flow in fibrous materials and wall structures is considered, the relevant equations being stated and the parts played by conduction, convection and radiation discussed. Some practical problems of insulation are mentioned. (C)